RF MICROWATTMETER

MODEL 42A

INSTRUCTION MANUAL

42A
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BOONTON ELECTRONICS CORPORATION

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CHAPTER I

INTRODUCTION

1.1 GENERAL

The Model 42A Microwattmeter provides an accurate means of measuring rf power from the low radio frequencies to the gigahertz region. Measurement capability extends from one nanowatt to ten milliwatts.

The 42A is a solid-state, programmable instrument of high sensitivity, exhibiting low input vswr, excellent stability, and low noise. The panel meter is calibrated in terms of power and dBm. A dc voltage proportional to the square root of the input power is available at the rear-panel connector; this feature allows the 42A to be connected into external systems such as recorders, remote indicators, or other analog devices.

The instrument offers an accurate and convenient means of making a variety of measurements. Representative uses of the 42A include:

Adjustment of low-power transmitters

VSWR and return-loss measurements with directional couplers and slotted lines

Gain and loss measurements on rf amplifiers

Measurements of vswr and attenuation of rf attenuators

Antenna adjustment

The Model 42A is available in several optional configurations. Standard features are:

Remote programmability
DC analog output
Low vswr
Convenient push-button ranging
Overload protection to 300 milliwatts
Measures from one nanowatt to ten milliwatts

The basic characteristics of instrument include high reliability, fast warm-up, long intervals between calibrations, plug-in printed-circuit boards for ease in servicing or modification, light weight, and other advantages of solid-state design.

1.2 EQUIPMENT DESCRIPTION

The Model 42A Microwattmeter functions by measuring the rf voltage appearing across an accurate, non-inductive resistance in the Power Detector head. The panel meter, of course, is calibrated in terms of power according to the relationship $P = E^2/R$.

The instrument is available with a range of options and Power Detectors, listed in Table 1, Chapter II. In all options input range programming can be controlled by external contact closures or PNP transistors to ground. It is sensitive, accurate, sturdily built and well protected against accidental overload. Performance over long periods of time without failure or need for recalibration is standard.

The Model 42A is packaged as a compact bench instrument. However, should rack mounting be desired, single and double rack-mounting kits are available designed for one or two Model 42A's.

Important accuracy and vswr information is reproduced on a reference plate attached to the outside top cover of the instrument. Calibration instructions are reproduced on the underside of the top cover.

The Model 42A is normally ordered with one of the following Power Detectors:

Model 41-4A	200 kHz to 7 GHz
Model 41-4B	200 kHz to 12.5 GHz
Model 41-4C	200 kHz to 1 GHz (75Ω)

1.2.1 Frequency Range

The calibrated frequency range extends from 200 kHz to 12.4 GHz, depending upon the particular Power Detector used. Useful response for relative measurements can be obtained from 20 kHz to beyond 14 GHz. See Figure 1 for accuracy and vswr charts.

1.2.2 Power Range

With any of the Power Detectors, the Model 42A will measure powers from one nanowatt up to ten milliwatts. Temporary overloads of up to 300 milliwatts will do no permament harm to the instrument or the Power Detector. When measuring pulsed signals, accuracy is good up to 30 microwatts peak power (15 microwatts average power).

The power capabilities of the 42A can be increased by the use of suitably designed attenuators.

1.2.3 Response

At low power levels the detector diodes operate in the square-law region; instrument response is to the average power level. Above the transition level of approximately ten microwatts response tends towards the peak value, although the panel meter is calibrated in terms of average power.

1.2.4 Noise

The Model 42A has been designed and built to hold noise from all sources to a minimum.

The Power Detector cable is of special low-noise design; a vigorous flexing causes only momentary, minor deflections on the most sensitive range of the instrument. The Power Detectors are not sensitive to shock or vibration; even sharp tapping on the Detector barrel causes no visible deflection on any range.

Amplification is done at 94 Hz, reducing susceptibility to 50 or 60 Hz fields. A unique circuit reduces the low-level noise originating in the mechanical chopper and renders the instrument immune to changes in chopper performance that could occur with the passage of time.

1.2.5 Minimal Zero Adjustment

Zero adjustment is not normally required on the upper ranges of the Model 42A. For measurements on the lower ranges, the ZERO control is set on the most sensitive range before commencing operation. This control balances out small thermal voltages in the sensing elements and, once adjusted, requires only infrequent checking during the course of subsequent measurements.

1.2.6 Analog Output

The Model 42A provides a dc output corresponding to the square root of the power being measured. The current capability of 1 mA into 1000 ohms is extremely stable. When used as part of an automatic test system, the fast response of the instrument's dc output to an input step function allows more tests per unit time.

For system or external requirements, all input and output connections for the Model 42A are made at the card-edge connector on the rear of the instrument cabinet. (See Figure 7 for receptacle connections)

POWER DETECTORS AND FREQUENCY RANGES

MODEL 41-4B: 50Ω, 0.2MHz TO 12.4GHz
MODEL 41-4A: 50Ω, 0.2MHz TO 7 GHz
MODEL 41-4C: 75Ω, 0.2MHz TO 1 GHz

ACCURACY

	0.1μW TO 10mW RANGE			10nW RANGE		
	0.5% f.s. PLUS			1% f.s. PLUS		
	0.2dB	0.3dB	0.4dB	0.4dB	0.6dB	0.8dB
WITH 41-4B DET:	0.2MHz 4GHz 8.2GHz 12.4GHz			0.2MHz 4GHz 8.2GHz 12.4GHz		
WITH 41-4A DET:	0.2MHz 4GHz 7GHz			0.2MHz 4GHz 7GHz		

TEMPERATURE INFLUENCES

TEMPERATURE RANGE	INSTRUMENT	DETECTOR
REFERENCE 21°C TO 25°C	0	0
NORMAL 18°C TO 30°C	0	±0.1dB
SEVERE 10°C TO 40°C	±0.2 dB	±0.2 dB

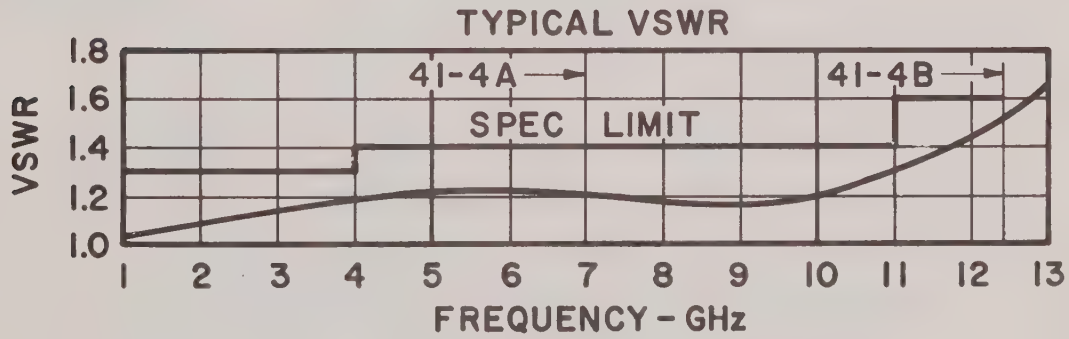


Figure 1. Accuracy and VSWR Specifications.

CHAPTER II

SPECIFICATIONS

Power Range: One nW (-60 dBm) to 10 mW (+10 dBm) in seven decade ranges.

Full Scale Power Ranges: 10 nW, 100 nW, 1 μW, 10 μW, 100 μW, 1 mW, 10 mW.

Full Scale dBm Ranges: -50, -40, -30, -20, -10, 0, +10.

Frequency Range: 0.2 MHz to 12.4 GHz with 41-4B Detector
0.2 MHz to 7 GHz with 41-4A Detector
0.2 MHz to 1 GHz with 41-4C Detector (75Ω)

Accuracy:

10 nW to 10 mW (-40 to 10 dBm)

	0.5% fs Plus		
	0.2 dB	0.3 dB	0.4 dB

With 41-4B	0.2 MHz	4 GHz	8.2 GHz	12.4 GHz
With 41-4A	0.2 MHz	4 GHz	7.0 GHz	
With 41-4C	0.2 MHz	1 GHz		

1 nW to 10 nW (-6- to -50 dBm)

	1% fs Plus		
	0.4 dB	0.6 dB	0.8 dB

With 41-4B	0.2 MHz	4 GHz	8.2 GHz	12.4 GHz
With 41-4A	0.2 MHz	4 GHz	7.0 GHz	
With 41-4C	0.2 MHz	1 GHz		

Meter: 4-1/2 inch taut-band
Two scales: dBm and Power
Top Scale (Red): -11 to 0 dBm, 0.2 dB or 0.5 dB divisions
Bottom Scale (Black): 1 to 10 with 1% or 2% divisions

Meter Unrest: 10 nW (-50 dBm) range:

Above 4 nW: 1% fs Max.
1 to 4 nW: 2% fs Max.

Power: 115 or 230 volts ±10%, 50 - 400 Hz, 8 watts.

RFI: There is no detectable radiated or conducted leakage from instrument or power detector.

Temperature: In accordance with ANSI (ASA) Spec. 39.7

Temperature Range	Influence	
	42A	Detector
Ref. 21°C - 25°C	0	0
Normal, 18°C - 30°C	0	±0.1 dB
Severe, 10°C - 40°C	±0.2 dB	±0.2 dB

Waveform Response: Input level 1 nW to 10 μW: True average power.

Input level above 10 μW: Average power of sine wave (true rms response changing to peak response)

Power Detectors: Input connection: Type N (Precision)
Output connector to fit 41-2A cable
Dimensions: 1.5" (38mm) diameter
3.5" (90mm) length

	Model 41-4A	Model 41-4B	Model 41-4C
Input Impedance	50Ω	50Ω	75Ω
Freq. Range	0.2 GHz - 7 GHz	0.2 MHz - 12.4 GHz	0.2 MHz - 1 GHz
VSWR	<1.3 to 4 GHz <1.4 to 7 GHz	<1.3 to 4 GHz <1.4 to 11 GHz <1.6 to 12.4 GHz	<1.3 to 1 GHz

(Calibration curves furnished with detectors)

DC Output: 0 to +10 volts on each range, proportional to the square root of input power.

Source resistance: 9 kΩ

DC Output (cont'd.)

1 mA max. into 1000Ω load

Response time to full-scale step function:
10 μW (-20 dBm) to 10 mW (+10 dBm) fs: 100 ms max.
Below 10 μW to 10 nW (-50 dBm) fs: 1 second max.

Programming:

Input range controllable by external contact closures or PNP transistor to ground.

Dimensions: 6.0" (152mm) high, 8.3" (211mm) wide, 12.0" (305mm) deep

Weight: Net 7 lbs. (3.2 kg) with standard accessories

Shipping weight 14 lbs. (6.4 kg)

Accessories supplied: 5-foot power detector cable Model 41-2A

Equipment Options: Model 42A-02: Logic level programming, 11 line logic level input, TTL/DTL compatible

Model 42A-11: Reverse scale option, power scale at top, dBm scale at bottom

Model 42A-08: Rear signal input

CHAPTER III

OPERATION

3.1 INSTALLATION

Each instrument has been inspected and tested at the factory for compliance with all specifications before packing. Should any indication of shipping damage appear when unpacking, be sure to notify the carrier immediately.

3.1.1 Operating Controls and Indicators

The controls and indicators of the 42A are shown in Table 1 below.

Table 1

Model 42A Controls & Indicators

ITEM	FUNCTION
PWR ON	This push-button switch turns on the instrument's power supply.
FULL SCALE	These range push-buttons select the operating range of the instrument. They are arranged in sequence 10 nW, 100 nW, 1 μW, 10 μW, 100 μW, 1 mW and 10 mW.
METER	A 4-1/2 inch taut-band meter with a linear Power scale reading 1 to 10 with 1% or 2% divisions, and a logarithimic dBm scale reading -11 to 0 dBm with 0.2 or 0.5 dB divisions.
POWER DETECTOR	The Power Detector cable in use is connected to the instrument through this jack. Always be sure that the knurled ferrule nut of the cable connector is tightened firmly.
ZERO	This control is used to zero the instrument electrically. (There is a mechanical zero-setting screw on the front of the meter housing)
The following items are on the rear panel:	
Fuse Holder and Fuse	A fuse holder is located on the rear panel for

Fuse Holder and Fuse (Cont'd.)	installation of either a 0.1 ampere, 115 volt, or 0.06 ampere, 230 volt Bussman MDL SLO-BLO fuse.
Slide Switch	This switches the power transformer primary to 115 or 230 volts, according to the available power source. Be sure that the proper fuse for the line voltage used is in the fuse holder.
Recorder Output	A DC voltage proportional to the square root of the applied power level is available at these terminals. Full-scale output is +10 volts; output resistance is 9000 ohms.
Remote Connections	A card-edge connector is accessible through a slot in the rear panel. Connection to this connector should be by means of an Amphenol 225-2221-101 connector, or equivalent. See Figure 6 for pin designations.
(Symbol on Rear Panel)	This safety requirement has been adopted by the International Electrotechnical Commission, Document 66 (Central Office) 3, paragraph 5.3, which directs that an instrument be so labelled if, for the correct use of the instrument, it is necessary to refer to the instruction manual. In this case it is recommended that reference be made to the instruction manual when connecting the instrument to the proper power source.

3.2 OPERATING PROCEDURE

In the following paragraphs the initial procedure to put the 42A into operation is described, as well as operating notes and measurement techniques.

3.2.1 Initial Operating Procedure

a. Be sure that the serial number of the Power Detector to be used is the same as that of the Model 42A. Each instrument is calibrated with its particular Detector. Use of a Detector other than the one for which the instrument has been calibrated may result in measurement errors unless the instrument is recalibrated.

b. If the panel meter pointer is not on zero, adjust it with the mechanical zero-set screw on the front of the meter housing.

c. Connect the Power Detector cable to the POWER DETECTOR jack on the panel, screwing the knurled clamping nut down firmly, and attach the Power Detector to the cable.

d. Check the setting of the power switch on the rear panel to be sure that it is set to the correct voltage position for the available power-line voltage, and the correct fuse is in the socket. Plug the instrument's power cable into a power receptacle.

e. Push in the PWR ON button.

f. Allow the instrument to warm up for a minute or so, then push the 10 nW FULL SCALE button. The meter needle should remain at the red/black zero reference mark at the extreme left-hand end of the scale. If it does not, use the ZERO control to set it to the mark.

Because of the instrument's sensitivity on this range, indicator fluctuation of up to ±0.5 dB can be expected; proper zero adjustment is achieved when the pointer fluctuates evenly around the zero reference mark. If the Detector is in a strong power-line or noise field, zeroing can be difficult. See Par. 3.2.7 for shielding instructions.

It is also important that the Detector be in thermal equilibrium; for this reason prolonged handling of the Detector should be avoided before or during this adjustment.

3.2.2 Connection Recommendations

All Power Detectors are equipped with a special Type N coaxial male connector for connection to the power source under study.

Although the Power Detectors are carefully insulated against external variations in temperature, it is advisable to locate the Detector away from any sources of heat when using the most sensitive ranges. If monitoring the output of equipment which generates heat significantly above the ambient temperature, the Power Detector should be connected by a sufficient length of cable to allow free circulation of air, rather than being fixed directly to a warm output connector. If this cannot be done, sufficient time should be allowed for the total assembly to reach thermal equilibrium before making any measurements.

3.2.3 Low Level Measurements

The Model 42A will provide reliable, reproducible measurements of cw power levels as low as 1 nanowatt (-60 dBm). It can also be used, although with slightly decreased accuracy (±1 dB) for pulse measurements. The peak power, however, should not exceed 30 μW (-18 dBm). Above these levels the detector enters the region where it functions as a peak detector; accuracy, except for cw, cannot be guaranteed under these conditions.

When using the three most sensitive ranges (10 nW, 100 nW, and 1 μW), the preliminary zero adjustment is required. This should be done as described in Par. 3.2.1.

3.2.4 High Level Measurements

When using the higher ranges of the instrument (10 μW to 10 mW) it is not necessary to make the zero adjustment. It should be noted that this instrument is not recommended for measuring pulse power where the peak exceeds 30 μW; errors may be incurred when pulses exceed the square-law response of the Power Detector diodes. For cw power, measurements within specified accuracy will be obtained up to 10 mW.

3.2.5 High Frequency Measurements

For specified accuracy above 1 GHz, the correction chart on the barrel of the Power Detector should be used. The correction factor given should be added algebraically to the meter reading. For example, if the meter reads -22.1 dBm at 3 GHz and the correction from the chart at 3 GHz is +0.2 dBm, the corrected value is -21.9 dBm.

NOTE

The Model 41-4A and 41-4B Power Detectors are calibrated for use with a 50-ohm source. Large deviations from 50 ohms may give rise to serious errors from mismatch and increased VSWR. This effect can be reduced by inserting a low-VSWR attenuator (VSWR < 1.10) between the source and the power detector; an alternative would be the insertion of a low-loss tuner.

The Model 41-4C Power Detector is calibrated for use with a 75-ohm source. The same comments apply in this case.

3.2.6 Temperature Effects

The accuracy specifications for the Model 42A apply over an ambient temperature ranging from 60° F to 90° F (16°C to 32°C). Operation outside this temperature range is possible, but some inaccuracy can be expected. Figure 2 shows a typical temperature characteristic of a Power Detector, and Figure 3 shows that of both the Model 42A and a Power Detector.

NOTE

For best zero stability, the Power Detector and instrument should be allowed to reach ambient temperature.

3.2.7 VSWR Measurements

The high frequency range and sensitivity of the Model 42A make it a useful instrument for measuring VSWR in conjunction with a slotted line. As this type of measurement requires only comparative values rather than absolute values, the 42A may be used up to 14 GHz.

The VSWR is determined by measuring the dB difference between a maximum and a minimum power point on a slotted line and converting this difference to VSWR. An adapter is needed to couple the instrument to the slotted line; these are usually available from the manufacturer of the particular slotted line used.

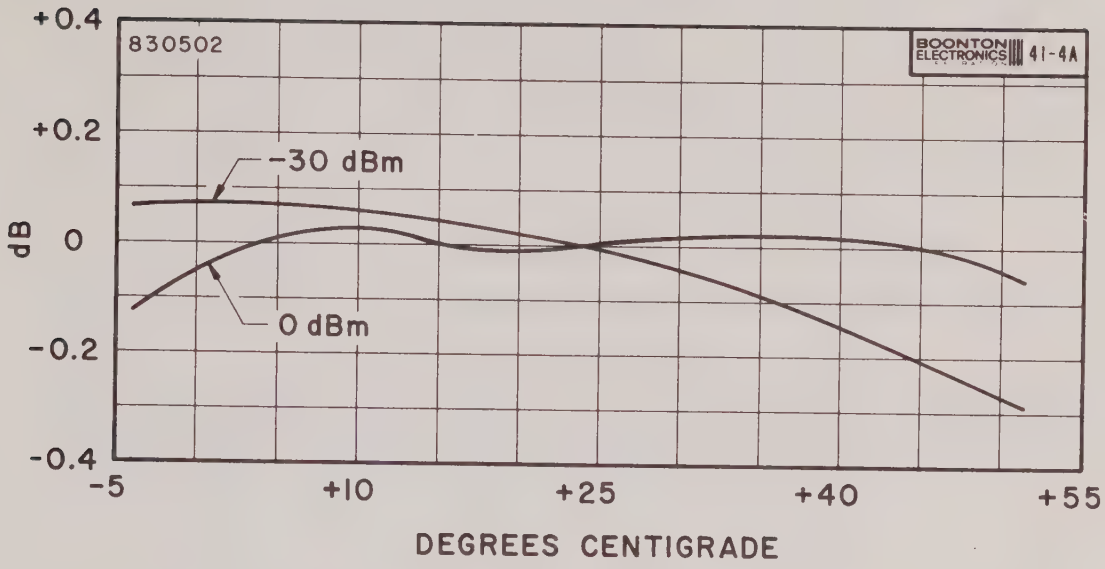


Figure 2. Detector Temperature Characteristic

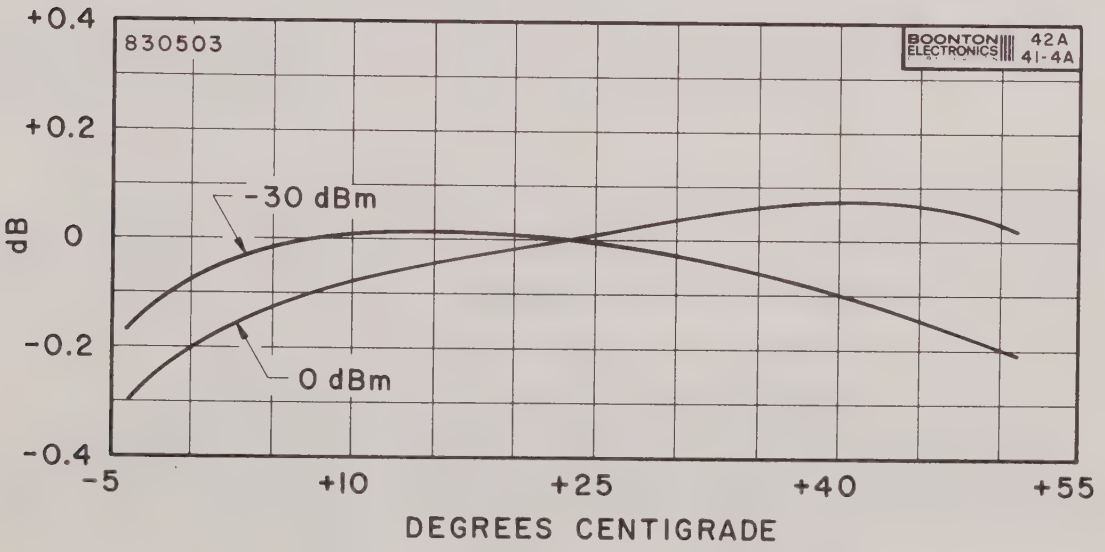


Figure 3. System Temperature Characteristic

Slotted-Line VSWR measurements may be made as follows:

a. Connect the Power Detector to the sliding carriage, using a suitable adapter.

b. With the signal source OFF, zero the Model 42A.

c. Turn the signal source on and slide the carriage along the line until a maximum power is located.

d. Adjust the probe setting for the least coupling that will yield a reading of -41 dBm. (Incident power should be 0 dBm or greater.

e. Adjust the source level until the 42A meter indicates -41 dBm (this is a convenient point).

f. Slide the carriage along the line to locate a power minimum. Note the meter reading (dBm) and subtract the minimum reading from the maximum reading, ignoring signs. Convert the resultant Δ dB into VSWR either reference to the VSWR Conversion Curve, Figure 4, or by computation.

Note: VSWR is the antilog, base 10, of ΔdB/20.

3.2.8 Making the Zero Adjustment

When making measurements on the three lowest ranges, or when setting up the instrument for the first time, the preliminary zero adjustment is required (Par. 3.2.1 and 3.2.3). If strong noise fields are present, it may be difficult to zero the instrument unless the Power Detector input is shielded from these fields.

The easiest means of shielding the detector is to connect it to the device being used for measurements, making sure that the device is turned off. Should the device itself act as an antenna and introduce additional noise signals, it is recommended that a shielded termination for the detector be made up with a Type N jack and some thin copper sheet.

3.2.9 DC Output

The dc output voltage at the rear terminals is proportional to the square root of the input power, or directly proportional to the input voltage. As the relationship between the meter reading and the output voltage, for either power or dBm, is not a linear one, the correction chart in Figure 5 must be used. This chart is also reproduced on the top cover of the 42A.

3.2.10 Logic Level Option (Model 42A-02)

The additional circuitry required for the Logic Level option is contained in an enclosure mounted on the rear panel of the instrument. The external connector, in this case, will mount on the top of the Logic Level enclosure. See Schematic diagram 830490 for the external connections.

Ranging and other functions are controlled by remote logic inputs;

logic 1 = +3.0V or more, and logic 0 = +0.3 V or less. The system is TTL-DTL compatible.

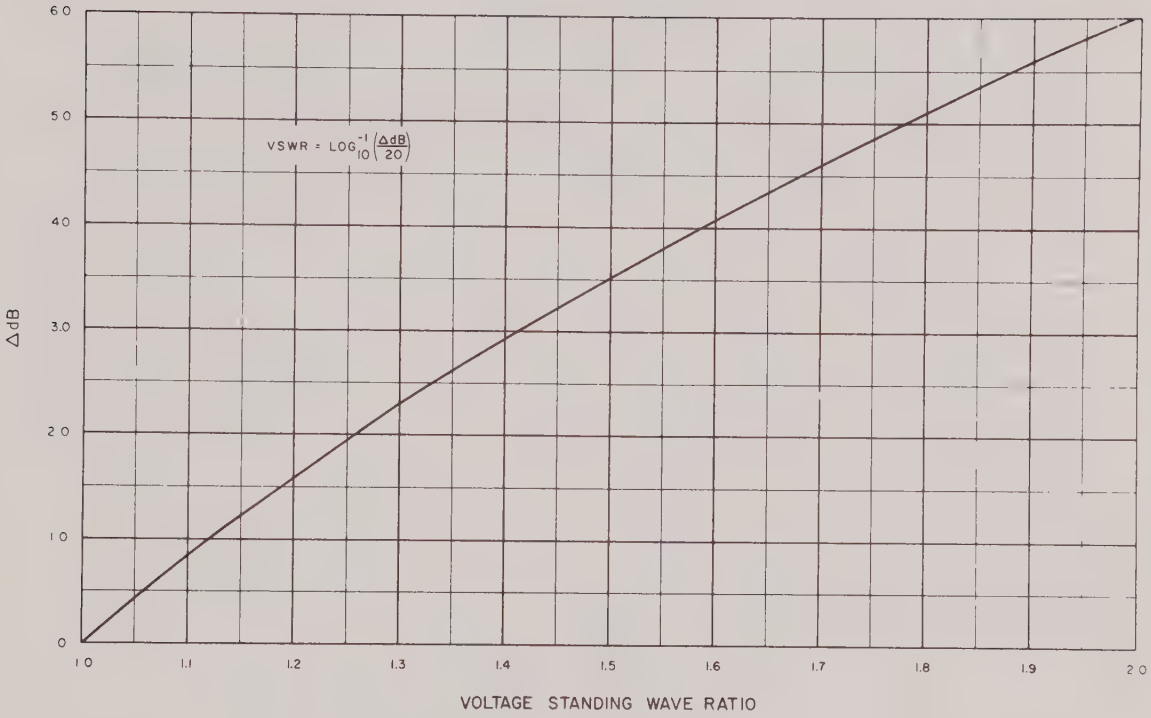


Figure 4. dB/VSWR Conversion Chart

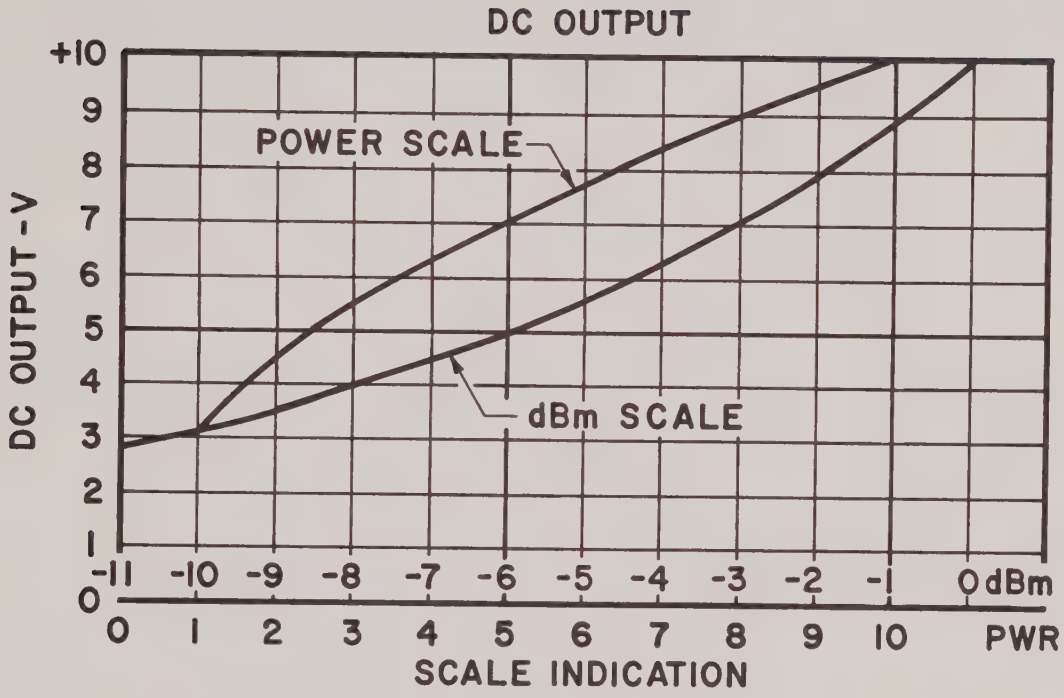


Figure 5. DC Output Correction Curve

CHAPTER IV

THEORY OF OPERATION

4.1 GENERAL

The basic elements of the Model 42A are shown in the block diagram reproduced below. The major components are the power detector, chopper, chopper driver, attenuator, preamplifier, amplifier, pulse generator, sync detector, shaping amplifier, power supply, and meter.

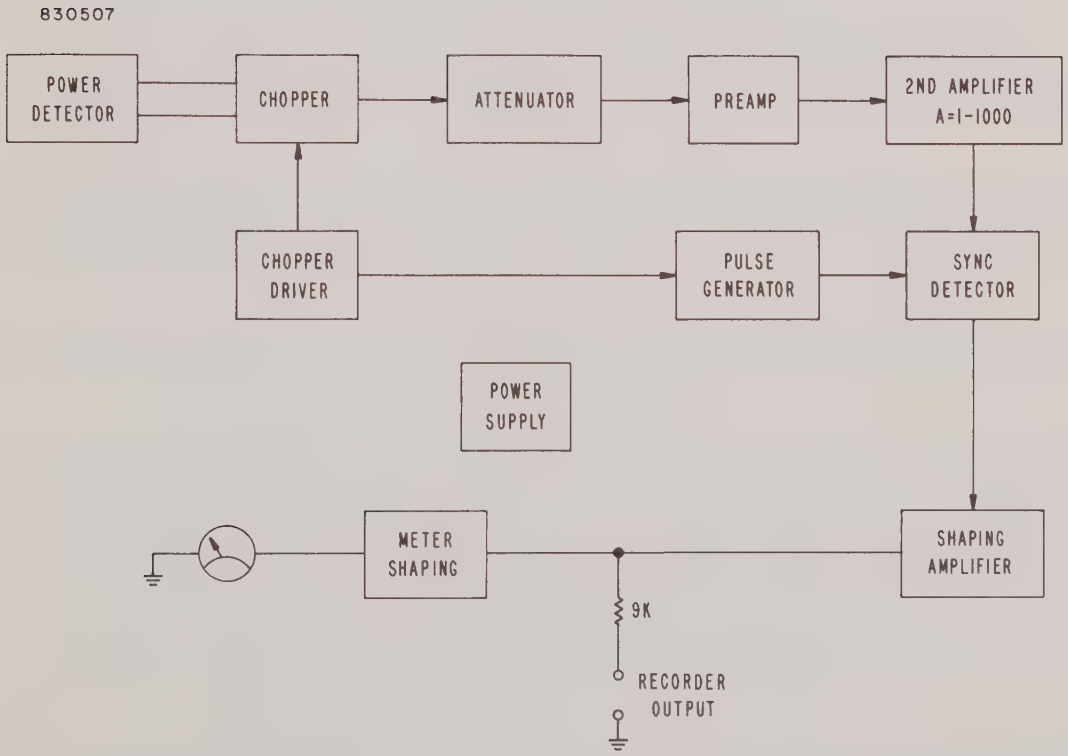


Figure 6. Block Diagram

4.1.1 Power Detector. The power detector unit contains a non-inductive load resistor and a pair of selected diodes connected as a full-wave rectifier. The rf voltage appearing across the load resistor is rectified by the diodes, producing a dc voltage whose level is a function of the input power level. When operation is in the square-law region (below approximately 15 microwatts) the detector provides true rms response. Above 15 microwatts the response gradually approaches peak-to-peak, calibrated on the meter scale in microwatts and dBm. The use of full-wave rectification permits measurement of highly asymmetrical waveforms without substantial errors.

The diodes used in the Power Detectors have been carefully selected for specific characteristics; the user is urged not to attempt their replacement. Should any of the components in the Power Detector suffer damage, call your local Boonton Electronics Sales Engineering Representative or the factory for instructions.

4.1.2 Attenuator and Amplifiers. The dc output voltage of the Power Detector is converted to ac by the mechanical chopper. This ac signal is applied to the attenuator and amplifier sections. For each range the output voltage from the second amplifier is approximately 3 volts peak-to-peak; this is done by ranging both the attenuation and the gain of the second amplifier.

The preamplifier has a constant gain of X100, and is designed for very low noise. Both amplifiers have moderately wide bandwidths, and are stabilized by large amounts of negative feedback.

4.1.3 Synchronous Detector. The amplified ac signal from the second amplifier is converted to dc by the synchronous detector; this is driven by pulses generated in the chopper-driver circuit, assuring exact synchronization. The peak-to-peak amplitude is derived from a shunt-series capacitor storage circuit using JFET switches.

The characteristics of the detector determine the effective bandwidth of the amplifier-detector combination and allow modification of the bandwidth for different range conditions. The detector also provides conversion without offset, with excellent linearity.

4.1.4 Shaping Amplifier. The conversion of rf to dc in the power detector is non-linear, the response being virtually square-law for the lowest ranges and gradually becoming quasi-linear for the 10 mW range. The shaping amplifier converts the non-linear output of the detector to a linear output by using a segmental approximation to the exact correction. The shaping amplifier is actually an operational amplifier so connected that, as the signal increases at its output, its gain is reduced by successively paralleling resistors across the feedback resistors. The number of segments required adequately to linearize the response varies from 6 for the "square-law" ranges down to 3 for the 10 mW range. The output of the shaping amplifier is +10 volts full scale, which drives the panel meter and is applied to the recorder terminals through a 9 kΩ resistor.

4.1.5 Chopper-Driver. These circuits provide the drive signals required by the instrument. The chopper driving frequency is obtained by dividing the output of a unijunction oscillator by two. The oscillator also generates the switching pulse for the synchronous detector; diode gating feeds the pulse to the proper JFET, depending on chopper phase.

4.1.6 Power Supply. The power supply converts the ac input power to regulated +15 and -15 volt outputs. Each supply is protected by current limiting against accidental short circuits. The +15 V supply is a zener-biased follower, and no adjustment is provided. The -15 V supply is referred to a 6.2 V zener, and the voltage is adjustable to -14.9V, +0.1V.

4.1.7 Programming. The instrument is organized around an eight-line ranging system. In each functional subcircuit the switching is done with solid-state devices, generally JFETs, which are actuated by the appropriate range line. The front panel range switch simply connects to the eight range lines to allow range selection. The range lines are extended to the rear of the instrument, terminating in a card-edge connector. The instrument may be ranged externally by grounding the appropriate line, with all front-panel range pushbuttons released.

It is recommended that an Amphenol 225-2221-101 connector, or equivalent, be used for remote programming connections.

4.1.8 Meter Shaping. On a linear meter, the accuracy is specified as a percentage of the full-scale indication; this means that a reading near the bottom of the scale will exhibit an appreciable absolute error. The Meter Shaping circuit acts to reduce this low-end arror by effectively compressing the range of the meter swing; the low end of each of the instrument's ranges is thereby set to a point appreciably above the low end of the meter scale. By this means the overall accuracy is maintained at a satisfactory level.

Figure 7. External Connections

CHAPTER V

MAINTENANCE

5.1 PERIODIC CALIBRATION. The Model 42 is designed to provide trouble-free operation over extended periods of time. However, as with any precision instrument, the instrument should be checked periodically to verify proper calibration.

5.2 CALIBRATION PRECAUTIONS. When checking the calibration of an instrument of the sensitivity and bandwidth of the 42, it is essential to take precautions against errors resulting from stray pick-up. A well-shielded signal source must be used together with coaxial connections.

5.3 CALIBRATION CHECK. Because of the outstanding low-frequency response of the Model 42 (200 kHz as opposed to the usual 10 MHz of competitive instruments) it is convenient to check the calibration by using voltage sources in the frequency range of 200 kHz to 500 kHz. In this range there are commercial sources and reference standards available with the required accuracy. Figure 7a shows the suggested equipment and connections to check all ranges of the Model 42 except the + 10 dBm range; figure 7b shows suggested equipment for the + 10 dBm range.

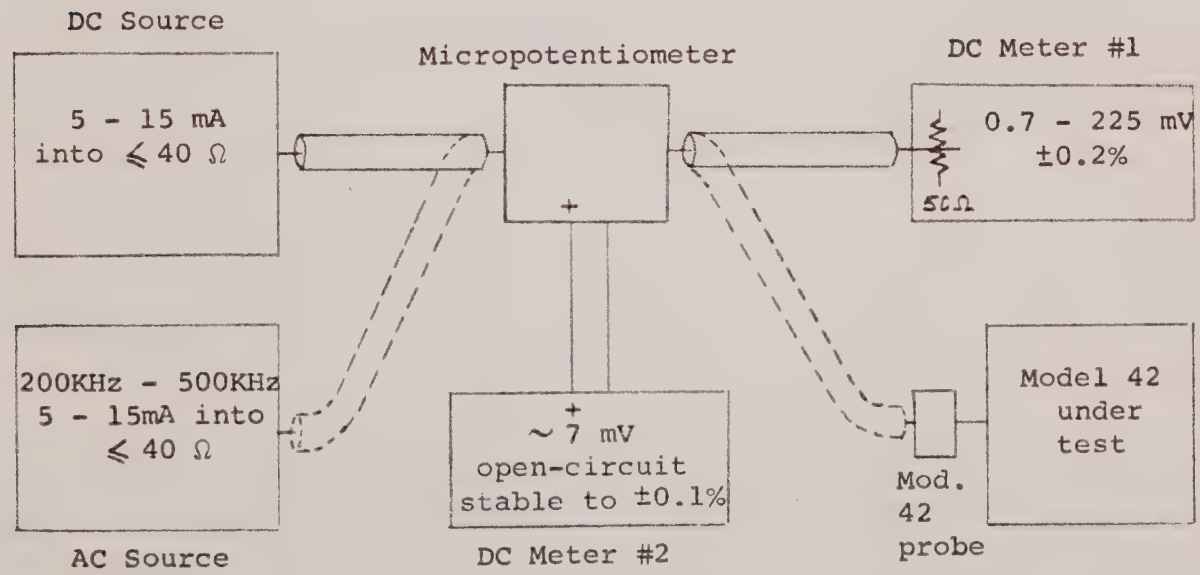


Figure 7a

Suggested Equipment:

DC SOURCE	HP6218A
AC SOURCE	HP209A
MICROPOTENTIOMETER	Ballantine Model 440 with 5 and 15 mA thermocouples and R = 140 mΩ, 1.4 Ω and 14 Ω
DC METER #1	HP Model 2402A Integrating DVM (pad for Z_{in} = 50 Ω)
DC METER #2	HP Model 419A DC Null Volt-Ammeter

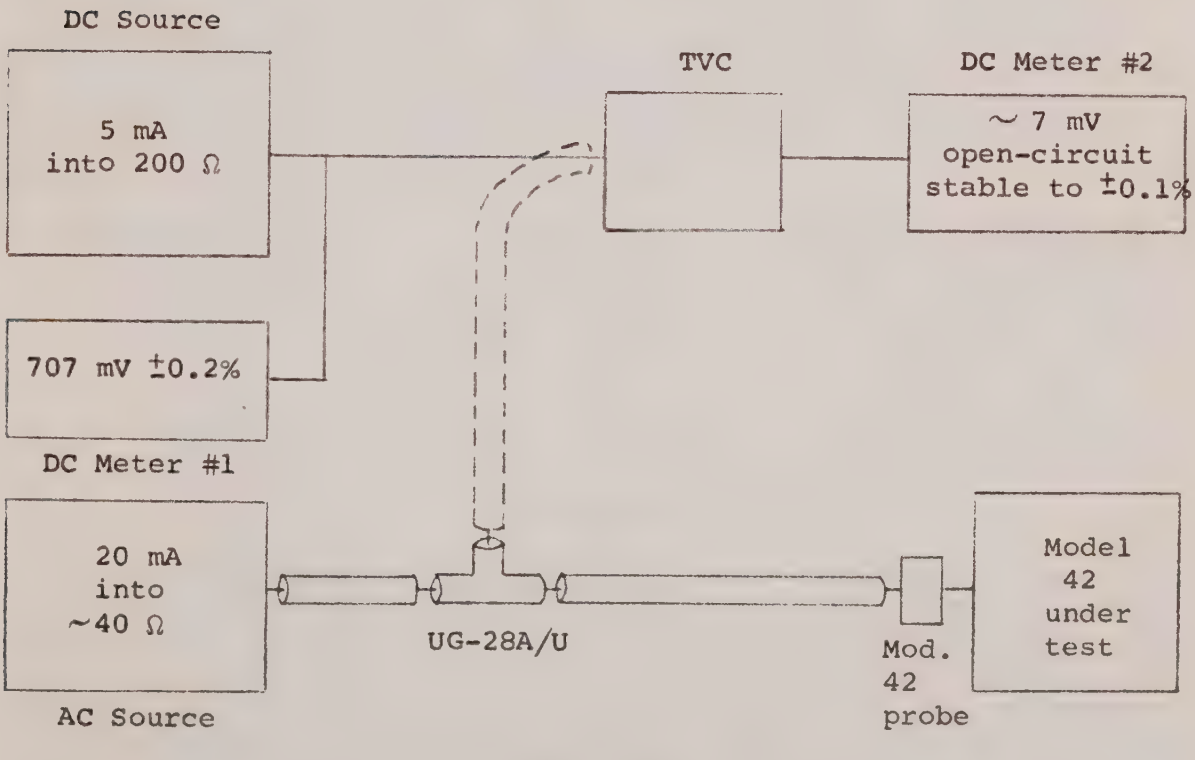


Figure 7b

Suggested Equipment:

DC SOURCE	HP 6218A
AC SOURCE	HP 209A
DC METER #1	HP Model 2402A Integrating DVM
DC METER #2	HP Model 419A DC Null Volt-Ammeter
TVC	Ballantine 1393-1 Thermal Voltage Converter

5.3.1 Calibration Check Procedure (All Ranges except +10 dBm) Each range is checked by connecting the appropriate micropotentiometer (thermocouple and radial resistor) to the dc source and dc meter #1 (see Figure 7a) and adjusting the source until the dc meter #1 reads the voltage equivalent to full-scale power for that range (see Figure 7c below). The reading of dc meter #2 is then recorded. Now connect the micropotentiometer to the ac source and Model 42 under test. Adjust the ac source until dc meter #2 indicates the same value as recorded above. The rms output voltage of the micropotentiometer is now equivalent to the dc voltage previously read on dc meter #1. The Model 42 should now read full-scale with the specified tolerances (±0.5% for the Model 42A, ±0.02 dB for the Model 42AD)

Model 42 FS Range	Model 440 T.C. Resistor	Voltage to Model 42 Equiv. to dc Meter #1
-50 dBm	5 mA 140 mΩ	.707 mV
-40	15 "	2.236
-30	5 1.4 Ω	7.071
-20	15 "	22.36
-10	5 14 Ω	70.71
0	15 "	223.6

Figure 7c

5.3.2 Calibration Check Procedure (+10 dBm Range) The +10 dBm range is checked by connecting the TVC to the dc source (see Figure 7b). The dc source is adjusted until dc meter #1 reads 707 mV. The reading of dc meter #2 is now recorded. Connect the TVC to the ac source tee. Adjust the ac source until dc meter #2 reads the same value as recorded above. The rms voltage now connected to the Model 42 will have a value equivalent to the 707 mV reading of dc meter #1. The Model 42 should now read full-scale within specified tolerances (±0.5% for Model 42A, ±0.02 dB for Model 42AD).

If the checks of paragraphs 5.3.1 and 5.3.2 show a range or ranges outside of specified tolerance, the following procedure should be followed, using the same equipment and techniques of section 5.3.

5.4 CALIBRATION PROCEDURE. The Model 42 should be calibrated at room temperature (approx. 74°F), after a minimum warm-up time of one minute.

The calibration outline shown in Figure 8 is repeated inside the top cover of the instrument; this outline lists in abbreviated form the steps described in the following procedure.

NOTE:

Check the mechanical zero of the Model 42 with the power off before making the following adjustments.

In the calibration instructions that follow, voltage values shown in parentheses apply to the 41-4C (75Ω) Power Detector.

Adjustment No. 1. Measure the -15.0 volt dc supply voltage at Test Point No. 5, located on the main amplifier board to the left of R145. Adjust R145 to -14.9 volts, ±0.1 volt.

Adjustment No. 2. Set the FULL SCALE range to -50 dBm and zero the instrument, as described in Paragraph 3.2.1.

Adjustment No. 3. Switch to the -20 dBm range. Adjust R233 for a zero meter reading.

Adjustment No. 4. Switch to the -50 dBm range, apply 0.707 mV, ±0.2%, and adjust R303 for a reading of -50 dBm. (0.866 mV)

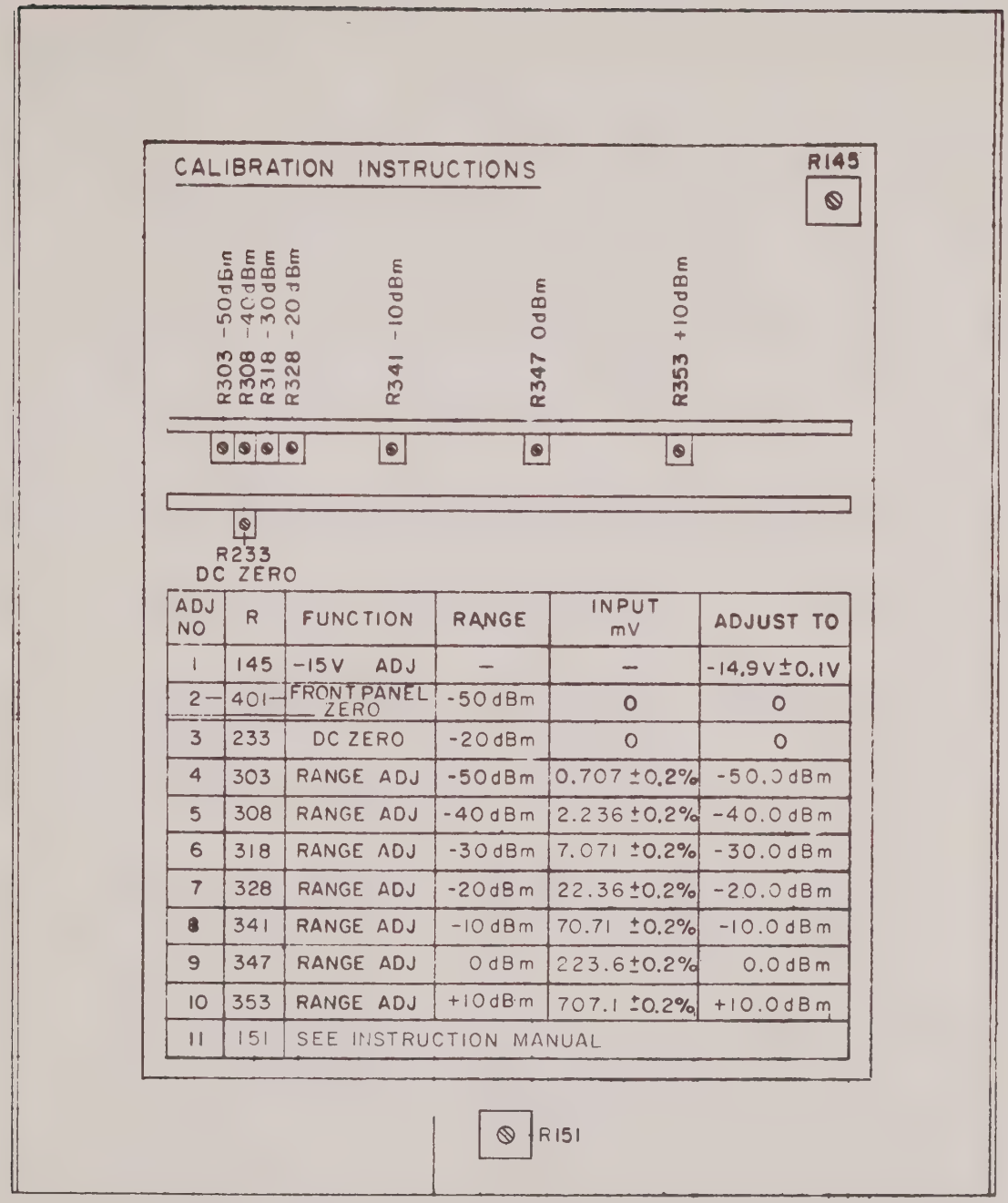
Adjustment No. 5. Switch to the -40 dBm range, apply 2.236 mV, ±0.2%, and adjust R308 for a reading of -40 dBm. (2.738 mV)

Adjustment No. 6. Switch to the -30 dBm range, apply 7.071 mV, ±0.2%, and adjust R318 for a reading of -30 dBm. (8.66 mV)

Adjustment No. 7. Switch to the -20 dBm range, apply 22.36 mV, ±0.2%, adjust R328 for a reading of -20 dBm. (27.38 mV)

Adjustment No. 8. Switch to the -10 dBm range, apply 70.71 mV, ±0.2%, and adjust R341 for a reading of -10 dBm. (86.60 mV)

Adjustment No. 9. Switch to the 0 dBm range, apply 223.6 mV, +0.2%, and adjust R347 for a reading of 0.0 dBm. (273.8 mV)



ADJ NO	R	FUNCTION	RANGE	INPUT mV	ADJUST TO
1	145	-15V ADJ	—	—	-14.9V±0.1V
2	401	FRONT PANEL ZERO	-50dBm	0	0
3	233	DC ZERO	-20dBm	0	0
4	303	RANGE ADJ	-50dBm	0.707 ±0.2%	-50.0dBm
5	308	RANGE ADJ	-40dBm	2.236 ±0.2%	-40.0dBm
6	318	RANGE ADJ	-30dBm	7.071 ±0.2%	-30.0dBm
7	328	RANGE ADJ	-20dBm	22.36 ±0.2%	-20.0dBm
8	341	RANGE ADJ	-10dBm	70.71 ±0.2%	-10.0dBm
9	347	RANGE ADJ	0dBm	223.6 ±0.2%	0.0dBm
10	353	RANGE ADJ	+10dBm	707.1 ±0.2%	+10.0dBm
11	151	SEE INSTRUCTION MANUAL			

Figure 8. Calibration Outline

Adjustment No. 10. Switch to the +10 dBm range, apply 707.1 mV, +0.2%, and adjust R353 for a reading of +10 dBm. (866.0 mV)

NOTE:

Adjustment No. 11 is made at the factory. It will only be required if a new Power Detector is to be used with the instrument.

Adjustment No. 11. Switch to the -30 dBm range, and apply an input of 7.071 mV, +0.2%. Measure the dc voltage at Test Point 17 on the Chopper Driver board; adjust R151 for a reading of 3.0 volts ac at this point. Proceed with Adjustments 1 through 10. (8.66 mV)

5.5 TROUBLE-SHOOTING PROCEDURE. If unsatisfactory operation of the Model 42A occurs, the following paragraphs outline the steps to be taken.

5.5.1 Cover Removal. Remove the instrument cover by taking out the screw located on the top of the case.

5.5.2 Chopper Replacement. Replace the chopper with a new one. (NOTE: The chopper used in the Model 42A is a special Boonton Electronics part. A replacement or spare chopper can be obtained from the local Boonton Electronics Representative or directly from the factory).

If a new chopper does not clear up the difficulty, place the original chopper back in the socket. If the new chopper eliminates the trouble, the calibration of the instrument should be checked before using.

5.5.3 Voltage and Resistance Tests. After eliminating the chopper as the source of trouble, a systematic check of the ac voltage, dc voltage and resistance values should be made. Test Points, wave forms, and related test voltages are shown on the Model 42A schematics.

When the trouble has been located and corrected, the calibration must be checked and if necessary, readjusted as described in Paragraph 5.4.

5.5.4. Replacement of Power Detectors. The Power Detector supplied with the 42A bears the same serial number as the instrument with which it was calibrated at the factory. If for any reason the Detector is to be changed, the calibration must be checked. In most cases full recalibration will be found necessary.

If trouble is suspected with the Power Detector, resistance measurements should be made at the RF input connector and the rear output connector to localize the trouble.

a. Measure the resistance of the RF input connector from center conductor to ground shell. $R_{in} = 50 \pm 1\ \Omega$.

b. Inspect the rear connector for possible damage. Measure the resistances from pins 1 and 2 to ground. $R_{out} > 10M\ \Omega$.

c. With a Simpson 260 on the 10K Ω range, measure the resistance from pin 1 (negative lead of 260) to pin 2 (positive lead of 260). $R_f = 20\text{-}30\ k\Omega$.

d. With a Simpson 260 on the 10K Ω range, measure the resistance from pin 1 (positive lead of 260) to pin 2 (negative lead of 260). $R_b > 400\ k\Omega$.

If the Power Detector passes the above tests, check all other possible failure sources (such as the Model 42, probe cable, connectors, RF power source, etc.) before proceeding with the following.

e. Remove the three 2-56 screws holding the outer shield. Slide the shield forward over the RF input connector.

f. Look for broken wires at this time. If any are found, repair and retest before proceeding.

g. The rear connector may now be replaced, if necessary, by removing the set screw at the side of the rear disc (the red mark on the side of the housing polarizes pin 1).

h. Remove the four 2-56 screws holding the inner shield. Slide the shield backwards from the main housing. Unsolder the wires at the teflon terminals, if necessary.

If the Power Detector failed the insulation test of b. above, look for a short to ground from the 1000 pF capacitors C102 and C103. These capacitors may be replaced by removing the two 0-80 screws on the side of the bracket. Tilt the housing to the side

so the bracket will fall away when a soldering iron is touched to the joint. The capacitor can now be easily replaced remote from the housing. Screw bracket to the housing before resoldering.

> CAUTION: Ground the soldering iron tip when soldering inside the probe housing to avoid damage to the diodes.

If the Power Detector failed the tests of c. or d. above, measure the resistance of the diodes CR101 and CR102 with a Simpson 260 on the 10 kΩ range. $R_f \sim 500\,\Omega$. $R_b \sim 50$ kΩ. Replace the diodes if the back resistance is much lower than 50 kΩ.

i. While grasping the diode with tweezers and applying a light upward force, touch the center post with a small high-temperature iron. The diode will lift when the solder melts. Now unsolder the far end of the resistor R103 or R104.

j. Retest the resistance measured in a. above. Replace R101 or R102 if necessary as follows.

Remove the four 2-56 screws holding the 100 Ω terminating resistors in place. Unsolder from center post by pulling the resistors from the rear while heating the center post. Overheating will cause distortion of the teflon spacer supporting the center conductor. Replace the new resistors in the reverse order.

k. Replace the diode/resistor networks by unsoldering the resistor ends first and then touching the center post as quickly as possible to unsolder the diode end.

After any critical parts such as diodes or terminating resistors are replaced, it will be necessary to check the input VSWR across the band. The test may be made with the shields off to facilitate adjustments.

1. Test the VSWR by any convenient method (slotted line, reflectometer, vector voltmeter, etc.) across the band. Adjust the length of the 100 Ω terminating resistor leads with the clamps on the top of the housing. Generally, longer leads increase VSWR at 6 and 7 GHz and decrease VSWR at 11 and 12 GHz. Adjust lead length for the best overall VSWR.

Variations in high-frequency response are covered by the application of Calibration Factor and Effective Efficiency, described in the following section.

5.6 HIGH FREQUENCY CALIBRATION. By following the procedures of paragraphs 5.3 and 5.4, and 5.5 if necessary, the Model 42 is now checked and calibrated to be within specified accuracy for low-frequency power measurements. The performance of the Model 42 at high frequencies is described in terms of corrections called Calibration Factor and Effective Efficiency. The following sections define these terms, explain their use and describe the calibration procedures required for their determination.

5.6.1 Calibration Factor and Effective Efficiency. Power measurements are made on either a Z_o match or conjugate match basis. On a Z_o match basis the measured power is given by:

$$P_{meas.} = \frac{(1-e)K\ P_o}{|1-\Gamma_G \Gamma_M|^2}$$

where $P_{meas.}$ = measured power
e = low frequency instrumentation error
Γ_G = complex generator reflection coefficient
Γ_M = complex power meter reflection coefficient
P_o = power that would be delivered to a perfect Z_o load
K = calibration factor

If the generator source impedance or power meter head provides a perfect Z_o match, the term $|1-\Gamma_G\Gamma_M|^2$ is unity. In all other cases the complex reflection coefficients have to be measured for the most accurate measurements or the uncertainty of measurement inherent in this term has to be accepted. Figures 9 and 10 show this uncertainty expressed either in dB or % in terms of the source and load VSWR, recalling that VSWR = $\frac{1+|\Gamma|}{1-|\Gamma|}$. In addition to the uncertainty, the mismatch loss associated with the power meter head is described by the calibration factor K_b where

$$K_b = \frac{\text{Indicated Power}}{\text{Incident Power}}$$

Uncertainty - DB $\dfrac{1}{(1 \pm |\Gamma_G||\Gamma_L|)^2}$

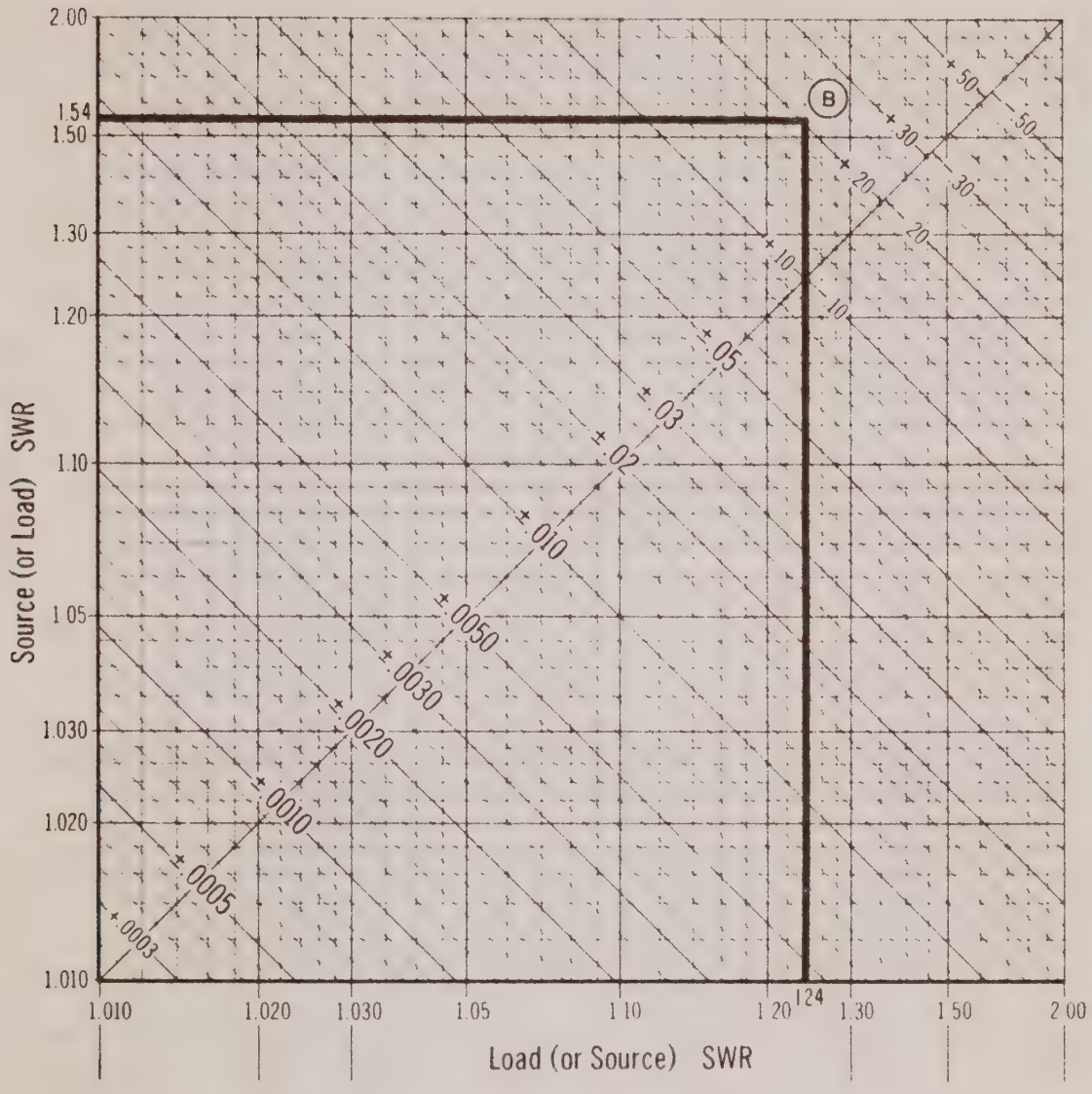


Figure 9

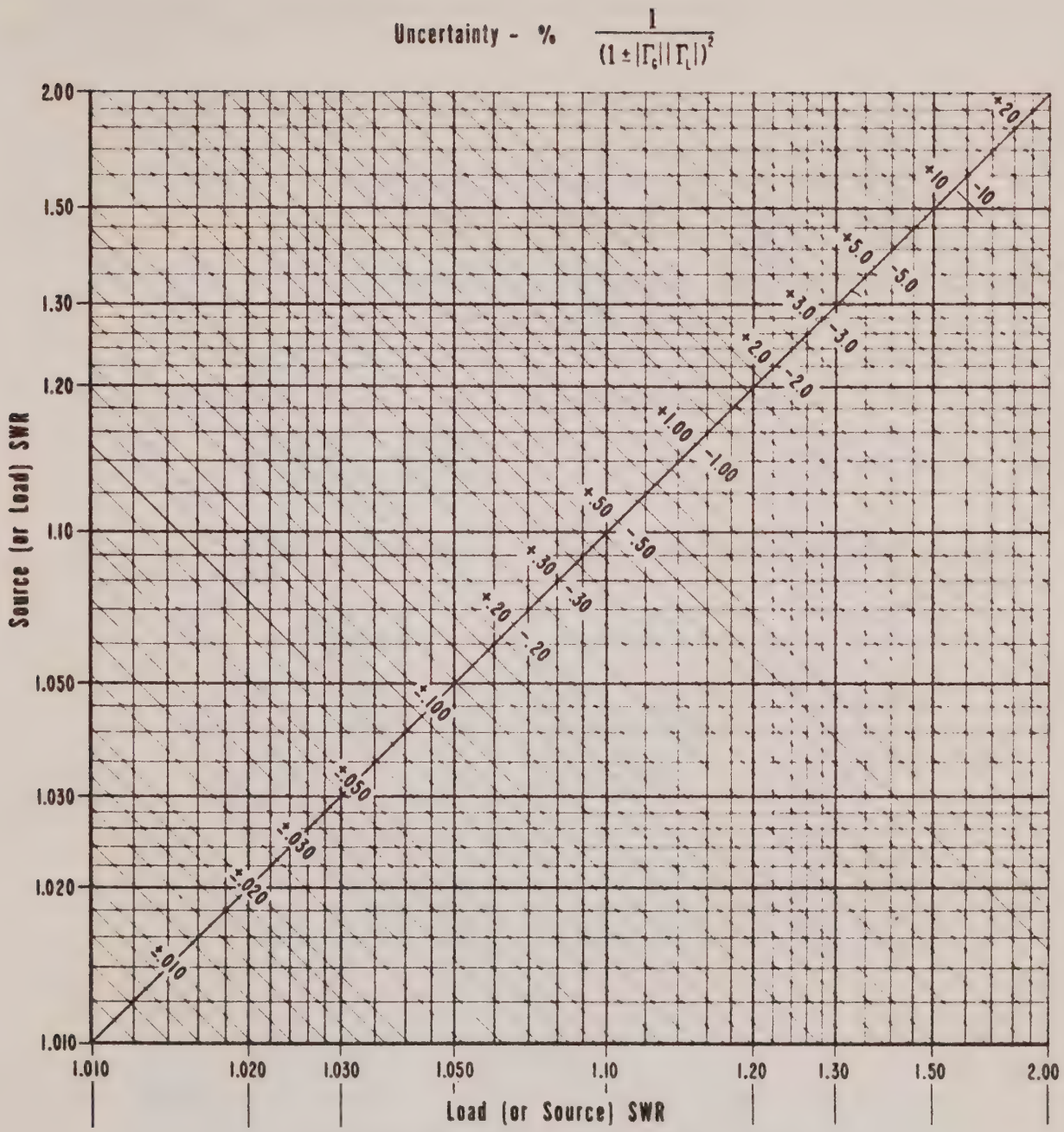
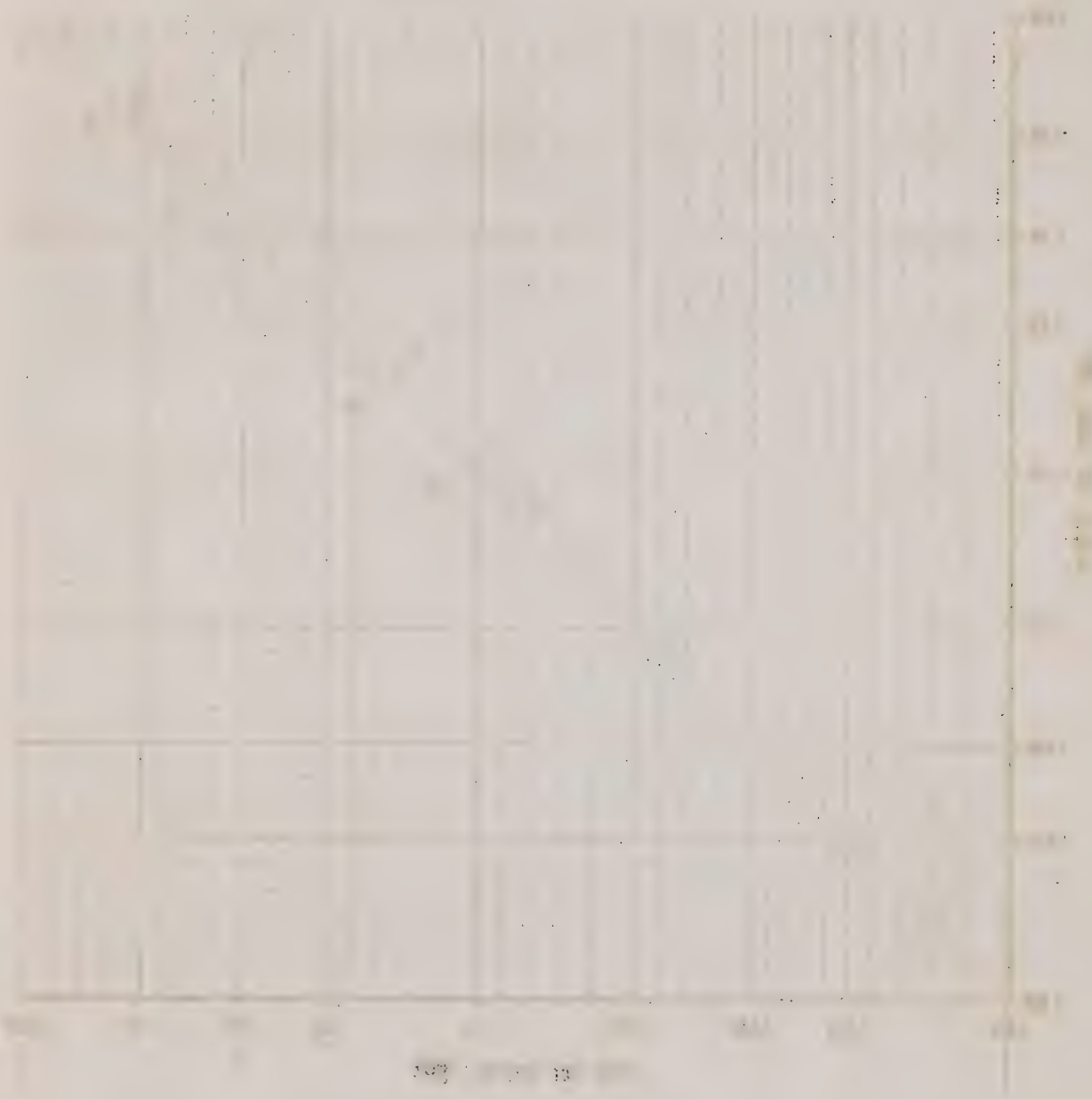

Uncertainty - % $\frac{1}{(1 \pm |\Gamma_s||\Gamma_L|)^2}$
Source (or Load) SWR
Load (or Source) SWR
2.00
1.50
1.30
1.20
1.10
1.050
1.030
1.020
1.010
1.010
1.020
1.030
1.050
1.10
1.20
1.30
1.50
2.00
±.010
±.020
±.030
±.050
±.100
±.20
±.30
±.50
±1.00
±2.0
±3.0
±5.0
±10
±20
-10
-5.0
-3.0
-2.0
-1.00
-.50
-.30
-.20

Figure 10



When power measurements are made on a conjugate match basis, the measured power is given by:

$$P_{meas.} = (1-e) K_T \eta P_C$$

where e = low frequency instrumentation error

K_T = tuner transmission characteristic

$$= \frac{\text{power delivered by tuner to load}}{\text{power delivered to tuner input}}$$

P_C = power that would be delivered to a perfect conjugate load

η = effective efficiency

The effective efficiency η is described by:

$$\eta = \frac{\text{Indicated Power}}{\text{Dissipated Power}}$$

The calibration factor and effective efficiency are related by the following equation:

$$K_b = (1-|\Gamma_M|^2)\,\eta$$

where $|\Gamma_M|$ is the absolute value of the power meter head reflection coefficient.

5.6.2 Determination of Calibration Factor

Required equipment:

1. Standard Power Meter. This is any suitable instrument (BE 42, HP 432, Gen. Micro. 454, PRD 6685, Narda 443, etc.) whose power head has been certified for Calibration Factor K_S by standards traceable to NBS and whose low-frequency instrumentation error e_1 is known.
2. Generator
3. Double-stub Tuner, Narda 903N
4. Directional Coupler, Weinschel Model 1538
5. Precision Termination, Weinschel Model 1404
6. 6 dB pad, Weinschel Model 1
7. Model 42 Power Meter (accuracy of calibration not important)
8. Model 42 to be calibrated
9. 50 Ω Termination, HP 909A

Connect the equipment as shown in Figure 11a.

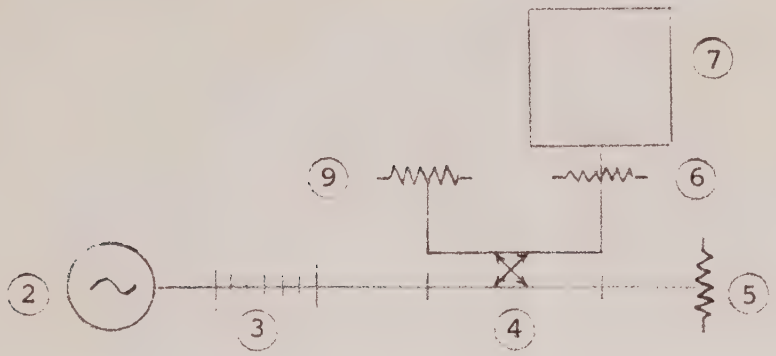


Figure 11a

1. Adjust the generator (2) to a convenient low frequency and a level sufficient for a stable reading on the Model 42 (7).

2. Adjust the stub tuner (3) for a maximum indication on the Model 42 (7).

   Connect the equipment as shown in Figure 11b.

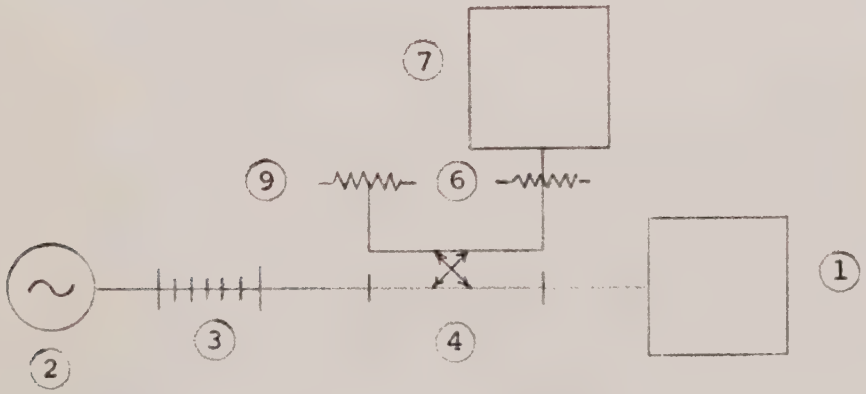


Figure 11b

3. At the same generator frequency as 1. above, adjust the generator level for a convenient level on the standard power meter (1). Record the output of the Model 42 (7). Record the indicated power P_{ind_1} of the standard power meter (1).

Connect the equipment as shown in Figure 11c.

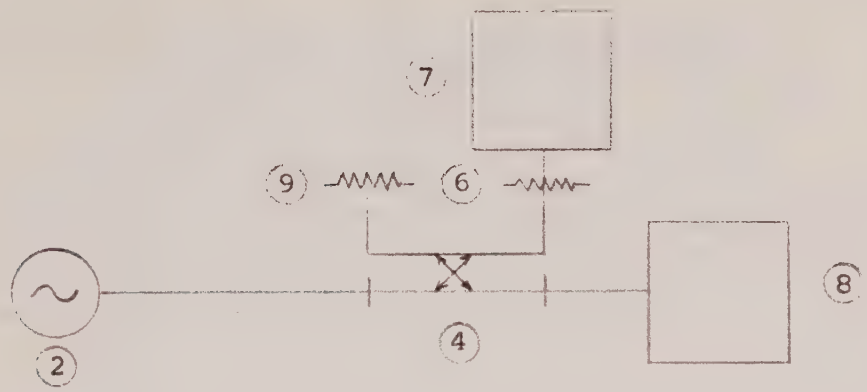


Figure 11c

4. At the same generator frequency as 1. and 3. above, adjust the generator level until the Model 42 (7) reads the value recorded in 3. above. Record the indicated power P_{ind_2} on the Model 42 to be calibrated (8).

The calibration factor K of the Model 42 is now computed from the relationship:

$$K = K_s \frac{(1-\mathcal{E}_2)\ P_{ind_2}}{(1-\mathcal{E}_1)\ P_{ind_1}}$$

where K_s = calibration factor of standard power meter
$\mathcal{E}_1$ = instrumentation error of standard power meter for the range used
P_{ind_1} = indicated power on standard power meter
$\mathcal{E}_2$ = instrumentation error of Model 42 for the range used as determined in 5.4.
P_{ind_2} = indicated power of Model 42

NOTE: It is important that the instrumentation error $\mathcal{E}_1$, of the standard power meter be known completely. For bolometer and thermocouple-type power meters, this error can usually be determined by dc substitution methods, as described by the manufacturers. In most cases, the uncertainty of instrumentation error can be improved by operating at higher power levels.

At all other frequencies of interest, repeat the steps 1. thru 4.

5.6.3 Determination of Effective Efficiency

Required equipment:

1. Generator
2. Directional Coupler, Weinschel Model 1538
3. 2 - 6 dB pads, Weinschel Model 1
4. 2 Model 42 Power Meters
5. Model 42 to be calibrated whose Calibration Factor has been determined according to section 5.6.2.

Connect the equipment as shown in Figure 12.

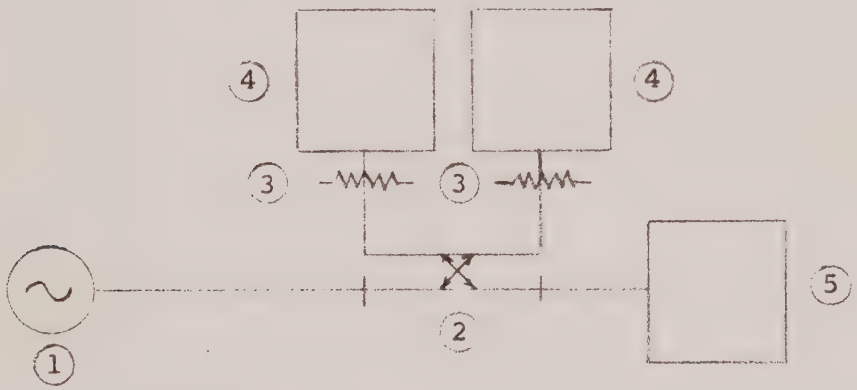


Figure 12

1. Set the generator to the first frequency of interest and increase its level for a convenient reading of the Model 42 (5) to be calibrated.

2. Measure the incident and reflected power on the two Model 42's and record these values as $P_{incident}$ and $P_{reflected}$. In recording these values correct the meter readings for the two 6 dB pads (3).

3. Calculate the magnitude of the reflection coefficient $|\Gamma_M|$ of the Model 42 to be calibrated according to:

$$|\Gamma_M| = \sqrt{\frac{P_{reflected}}{P_{incident}}}$$

The effective efficiency η is now given by:

$$\eta = \frac{K}{1 - |\Gamma_M|^2}$$

where K is the calibration factor as determined in section 5.6.2.

At all other frequencies of interest, repeat steps 1. thru 3.

This completes the high frequency power calibration of the Model 42.

MODEL 41-4B POWER DETECTOR

TABLE OF REPLACEABLE PARTS

Reference		Description		BEC Part No.
C101	Capacitor	400 pF GMV 50V	Amer. Lava T-176A, TC-25V	224127
C102	"	1000 pF 20% 50V	Vitramon VK11CX102-M	224126
C103	"	1000 pF 20% 50V	Vitramon VK11CX102-M	224126
CR101/ R103	Diode/ Resistor	Network, Neg.	Boonton Electronics Special	530901
CR102/ R104	Diode/ Resistor	Network, Pos.	Boonton Electronics Special	530902
R101	Resistor	100 Ω ± 1% 1/20W	Boonton Electronics Special	324121
R102	"	100 Ω ± 1% 1/20W	Boonton Electronics Special	324121
R105	"	10 K ± 5% 1/8W	AB EB	331106
R106	"	10 K ± 5% 1/8W	AB EB	331106

TABLE OF REPLACEABLE PARTS

Reference		Description		BEC Part No.
A201	Operational Amplifier		Nat. Semi. LM302	535003
A301	" "		" " LM301A	535002
C101	Capacitor	0.1 µF ± 10% 200V	Sprague 192P10402	234005
C102	"	10 µF ± 20% 20V	Kemet K01E20	283205
C103	"	100 pF ±5% 500V	Arco DM15101-J	200001
C104	"	10 µF ± 20% 20V	Kemet K10E20	283205
C105	"	33 µF ± 20% 15V	Kemet K33E15	283206
C106	"	10 µF ± 20% 20V	Kemet K10E20	283205
C107	"	1.0 µF ± 20% 100V	Electron Prod. W1-105	236007
C108	"	1.0 µF ± 20% 35V	Kemet K1E35	283199
C109	"	50 µF 25V	Sprague TE1209	283159
C110	"	50 µF 25V	Sprague TE1209	283159
C111	"	0.1 µF ± 10% 200V	Sprague 192P10402	234005
C112	"	250 µF 40V	Mallory Type PFP	283207
C113	"	250 µF 40V	Mallory Type PFP	283207
C114	"	100 µF 25V	Sprague TE1211	283105
C115	"	100 µF 25V	Sprague TE1211	283105
C201	"	0.1 µF ± 10% 50V	TRW 463UWU	234046
C202	"	0.0068 µF ± 10% 200V	Sprague 192P68292	234044
C203	"	100 pF ± 5% 500V	Arco DM15F101-J	200001
C204	"	100 pF ± 5% 500V	Arco DM15F101-J	200001
C205	"	0.022 µF ± 10% 200V	Sprague 192P22392	230101
C206	"	0.1 µF ± 10% 50V	TRW 463UWU	234046
C207	"	100 pF ± 5% 500V	Arco DM15F101-J	200001
C208	"	0.1 µF ± 10% 50V	TRW 463UWU	234046
C209	"	0.01 µF DISC. 100V	Erie 805-15V01032	224119
C210	"	0.01 µF DISC. 100V	Erie 805-15V01032	224119
C211	"	0.018 µF ± 5% 200V	Sprague 192P18352	234064
C212	"	0.22 µF ± 10% 50V	TRW 463UWU	234075
C213	"	100 pF ± 5% 500V	Arco DM15F101-J	200001
C214	"	50 µF 25V	Sprague TE1209	283159
C215	"	50 µF 25V	Sprague TE1209	283159
C216	"	50 µF 25V	Sprague TE1209	283159
C301	"	0.01 µF 100V	Erie 805-Y5V01032	224119
C302	"	33 pF ± 5% 500V	Arco DM-15-330-J	200049
C303	"	0.01 µF 100V	Erie 805-Y5V01032	224119

Reference		Description		BEC Part No.
C401	Capacitor	0.1 µF ±10% 50V	TRW 463 UWU	234046
C402	"	0.1 µF ±10% 50V	TRW 463 UWU	234046
CR101	Diode	L Pwr. PIV 125 450 mA	Fairchild FD300	530052
CR102	"	L Pwr. Silicon	Texas Inst. 1N914	530058
CR103	"	L Pwr. Silicon	Texas Inst. 1N914	530058
CR104	", Zener	11V ±5% 500 mW	Motorola 1N5241B	530082
CR105	", Zener	6.8V ±5% 500 mW	Motorola 1N5235B	530089
CR106	Diode	L Pwr. Silicon	T. I. 1N914	530058
CR107	Rectifier, Sil.	1.5A 200V	Gen. Inst. KBP02	532013
CR108	Diode	L Pwr. Silicon	T. I. 1N914	530058
CR109	"	L Pwr. Silicon	T. I. 1N914	530058
CR110	"	L Pwr. Silicon	T. I. 1N914	530058
CR111	"	L Pwr. Silicon	T. I. 1N914	530058
CR112	Diode, Zener	16V ±5% 500 mW	Motorola 1N5246B	530090
CR113	" "	6.2V ±5% 500 mW	Motorola 1N5234B	530093
CR201	Diode	L Pwr., Silicon	T. I. 1N914	530058
CR202	"	" "	"	"
CR203	"	" "	"	"
CR204	"	" "	"	"
CR205	"	" "	"	"
CR206	"	" "	"	"
CR207	"	" "	"	"
CR208	"	" "	"	"
CR209	"	" "	"	"
CR210	"	" "	"	"
CR211	"	" "	"	"
CR212	"	" "	"	"
CR213	"	" "	"	"
CR214	"	" "	"	"
CR215	"	" "	"	"
CR216	"	" "	"	"
CR217	"	" "	"	"
CR218	"	" "	"	"
CR219	"	125 P.I.V. 450 mA	Fairchild FD300	530052
CR301	Diode	L Pwr., Silicon	T.I. 1N914	530058
CR302	"	" "	"	"
CR303	"	" "	"	"
CR304	"	" "	"	"

Reference		Description		BEC Part No.
CR305	Diode	L Pwr., Silicon	T.I. 1N914	530058
CR306	"	" "	"	"
CR308	"	" "	"	"
CR401	Diode	L Pwr., Silicon	T.I. 1N914	530058
CR402	"	" "	"	"
CR403	"	" "	"	"
CR404	"	" "	"	"
CR405	"	" "	"	"
CR406	"	" "	"	"
CR407	"	" "	"	"
CR408	"	" "	"	"
CR409	"	" "	"	"
CR410	"	" "	"	"
DS401	Lamp		Tungsol 349	545107
DS402	"		"	"
F401	Fuse	1/10A 117V	Bussman MDL Slo-Blo	545519
or				
F401	Fuse	1/16A 220V	Bussman MDL Slo-Blo	554518
G401	Chopper	Special	Airpax, Type 3 6	540113
J101	Connector	Card Edge, 22 Pos.	Amphenol 143-022-03	479231
J102	"	" " "	" "	"
J401	Receptacle		Amphenol 80-PC-2-FT	479119

Reference	Description		BEC Part No.
M401	Meter & Scale		554228
Q101	FET	Junction, Silicon	Motorola 2N5459	528019
Q102	"	" "	" "	"
Q103	"	" "	" "	"
Q104	"	Silicon, N-Channel	T.I. S 58	528038
Q105	"	MOS-FET	Hughes HDGP-1001	528057
Q106	"	Junction, Silicon	Motorola 2N5459	528019
Q107	Transistor	Selected, Special		528044
Q108	"	NPN, Silicon	Motorola 2N5088	528047
Q109	"	PNP, Silicon	Motorola 2N5087	528042
Q110	"	PNP	Motorola MPS-A66	528048
Q111	"	PNP, Silicon	Motorola 2N5087	538042
Q112	"	NPN, Silicon	Motorola 2N5088	528047
Q113	FET	N-Channel, Silicon	T.I. TIS58	528038
Q114	"	N-Channel, Silicon	T.I. TIS58	528038
Q115	"	N-Channel, Silicon	T.I. TIS58	528038
Q116	"	Junction, Silicon	Motorola 2N5459	528019
Q117	"	" "	"	"
Q118	"	" "	"	"
Q119	Transistor	PNP	" MPS-A66	528048
Q120	"	NPN, Silicon	" 2N3903	528024
Q121	"	PNP, Silicon	" 2N3905	528025
Q122	FET	Junction, Silicon	" 2N5459	528019
Q123	"	" "	" "	528019
Q124	Transistor	NPN, Silicon	" 2N4921	528034
Q125	"	PNP, Silicon	" 2N4918	528033
Q126	"	PNP, Silicon	" 2N5087	528042
Q127	FET	MOS-FET	Hughes HDGP-1001	528057
Q201	Transistor	Unijunction, Silicon	Motorola 2N4871	528051
Q202	"	NPN, Silicon	" MPSA10	528043
Q203	"	PNP, Silicon	Motorola 2N5087	528042
Q204	"	NPN, Silicon	" 2N5088	528047
Q205	"	NPN, Silicon	" MPSA10	528043
Q206	FET	Silicon	Motorola, MPS-A12	528052
Q207	Transistor	NPN, Silicon	Motorola, MPSA10	528043
Q208	"	N-Channel, Junction	T.I. TIS58	528038
Q209	"	NPN, Silicon	Motorola MPSA10	528043
Q210	"	N-Chanel, Junction	T.I. TIS58	528038
Q211	FET	Junction, Silicon	Motorola 2N5459	528019
Q212	Transistor	NPN, Silicon	" MPSA10	528043

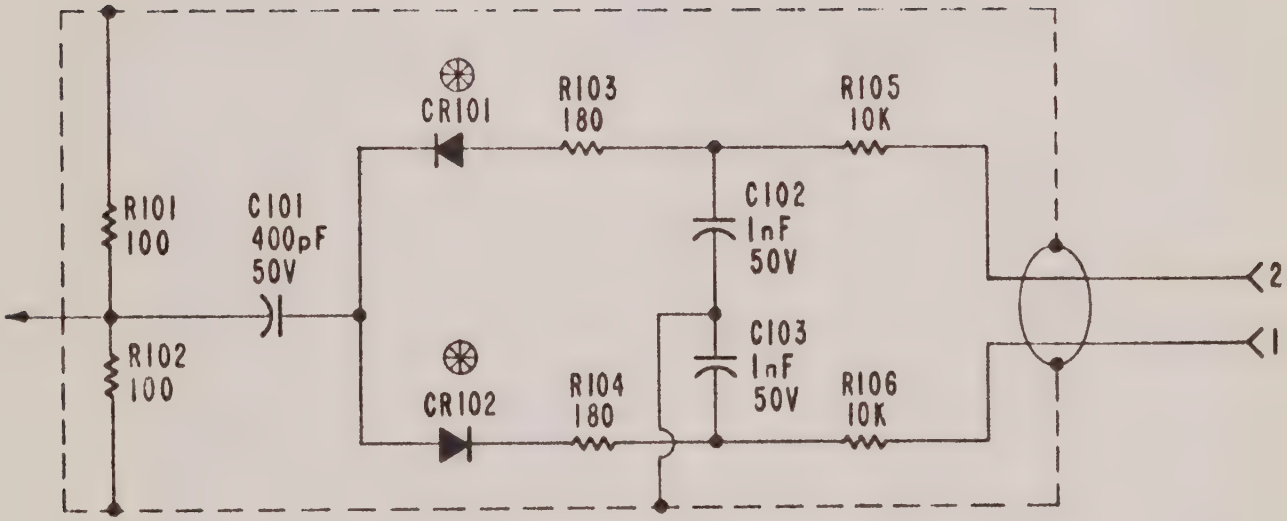
Reference		Description		BEC Part No.
Q213	Transistor	NPN, Silicon	Motorola 2N5308	528050
Q214	"	NPN, Silicon	" 2N5308	"
Q301	FET	Junction, Silicon	Motorola 2N5459	528019
Q302	"	" "	" "	"
Q303	"	" "	" "	"
Q304	Transistor	PNP, Silicon	Motorola 2N5087	528042
Q305	FET	Junction, Silicon	" 2N5459	528019
Q306	Transistor	PNP, Silicon	" 2N5087	528042
Q307	FET	Junction, Silicon	" 2N5459	528019
Q308	Transistor	PNP, Silicon	" 2N5087	528042
Q309	FET	Junction, Silicon	" 2N5459	528019
Q310	Transistor	PNP, Silicon	" 2N5087	528042
Q311	FET	Junction, Silicon	" 2N5459	528019
Q312	Transistor	PNP, Silicon	" 2N5087	528042
Q313	FET	Junction, Silicon	" 2N5459	528019
Q314	"	" "	" "	"
Q315	"	" "	" "	"
Q316	"	" "	" "	"
Q317	Transistor	PNP, Silicon	" 2N5087	528042
Q318	"	NPN, Silicon	" 2N5088	528047
Q319	"	PNP, Silicon	" 2N5087	528042
Q320	"	NPN, Silicon	" 2N5088	528047
Q321	"	PNP, Silicon	" 2N5087	528042
Q322	"	PNP, Silicon	" 2N5087	528042
Q323	FET	Junction, Silicon	" 2N5459	528019
Q324	"	" "	" "	"
Q325	Transistor	PNP, Silicon	" 2N5087	528042
Q326	FET	Junction, Silicon	" 2N5459	528019
Q327	Transistor	PNP, Silicon	" 2N5087	528042
Q328	FET	Junction, Silicon	" 2N5459	528019
Q329	Transistor	PNP, Silicon	" 2N5087	528042
Q330	FET	Junction, Silicon	" 2N5459	528019
Q331	"	" "	" 2N5459	528019
Q332	Transistor	PNP, Silicon	" 2N5087	528042
Q333	"	" "	" 2N5087	528042
Q334	"	" "	" 2N5087	"
Q338	Transistor	PNP, Silicon	" 2N5087	528042
Q339	"	" "	" "	"
R101	Resistor	1M 1/2W 5%	AB EB	301159
R102	"	3.9 kΩ 1/4W 5%	AB CB	300096
R103	"	3.9 kΩ 1/4W 5%	AB CB	300096
R104	"	5.62M 1/4W 1%	Pyrofilm MPE65	325397

Reference		Description		BEC Part No.
R106	Resistor	57.6 kΩ 3/8W 1%	T.I. MC60D	340450
R107	"	267 kΩ 3/8W 1%	T.I. MC60D	340530
R108	"	68.1 kΩ 3/8W 1%	T.I. MC60D	340458
R109	"	1.00M 3/8W 1%	T.I. MC60D	326700
R110	"	91 K 1/2W 5%	T.I. MC60D	301134
R111	"	41 K 1/2W 5%	T.I. MC60D	301127
R112	"	33 K 1/2W 5%	T.I. MC60D	301123
R113	"	300 K 1/2W 5%	T.I. MC60D	301146
R114	"	150 Ω 3/8W 1%	T.I. MC60D	340141
R115	"	10 K 1/2W 5%	AB EB	301111
R116	"	10 K 1/2W 5%	AB EB	301111
R117	"	33 K 1/2W 5%	AB EB	301123
R118	"	15 K 3/8W 5%	T. I. MC60D	340378
R119	"	15 K 1/2W 5%	AB EB	301115
R120	"	3.6 K 1/2W 5%	AB EB	301100
R121	"	3 K 1/2W 5%	AB EB	301098
R122	"	1 M 1/2W 5%	AB EB	301159
R123	"	2.7 K 1/2W 5%	AB EB	301097
R124	"	5.6 K 1/2W 5%	AB EB	301105
R125	"	5.6 K 1/2W 5%	AB EB	301105
R126	"	470 Ω 1/2W 5%	AB EB	301079
R127	"	5.1 K 1/2W 5%	AB EB	301104
R128	"	15 K 1/2W 5%	AB EB	301115
R129	"	1 K 1/2W 5%	AB EB	301087
R130	"	10 K 1/2W 5%	AB EB	301111
R131	"	30.1 K 3/8W 1%	T.I. MC60D	326397
R132	"	3.01 K 3/8W 1%	T.I. MC60D	326397
R133	"	301 Ω 3/8W 1%	T.I. MC60D	340176
R134	"	33.2 Ω 3/8W 1%	T.I. MC60D	340063
R135	"	1 M 1/2W 5%	AB EB	301159
R136	"	2 K 1/2W 5%	AB EB	301094
R137	"	24 K 1/2W 5%	AB EB	301120
R138	"	24 K 1/2W 5%	AB EB	301120
R139	"	2 K 1/2W 5%	AB EB	301094
R140	"	8.2 Ω 1/2W 5%	AB EB	301505
R141	"	8.2 Ω 1/2W 5%	AB EB	301505
R142	"	100 Ω 1/4W 5%	AB CB	300058
R143	"	100 Ω 1/4W 5%	AB CB	300058
R144	"	3.92 K 3/8W 5%	T. I. MC60D	340311
R145	"	1 K 1/2W 20%	CTS 360T102B	311257
R146	"	4.75 K 3/8W 1%	T.I. MC60D	340321
R148	"	9.09 K 3/8W 1%	T.I. MC60D	340354
R149	"	150 kΩ 1/2W 5%	AB EB	301139
R150	"	100 Ω 3/8W 1%	T.I. MC60D	326031
R151	"	100 Ω 1W 20%	CTS 360PC101B	311258

Reference		Description		BEC Part No.
R201	Resistor	10 K 1/2W 5%	AB EB	301111
R202	"	33 K 1/2W 5%	AB EB	301123
R203	"	10 K 1/2W 5%	AB EB	301111
R204	"	100 Ω 1/2W 5%	AB EB	301063
R205	"	33 K 1/2W 5%	" "	301123
R206	"	10 K 1/2W 5%	" "	301111
R207	"	100 K 1/2W 5%	" "	301135
R208	"	3.3 K 1/2W 5%	" "	301099
R209	"	4.7 K 1/2W 5%	" "	301103
R210	"	10 K 1/2W 5%	" "	301111
R211	"	150 K 1/2W 5%	" "	301139
R212	"	10 K 1/2W 5%	" "	301111
R213	"	10 K 1/2W 5%	" "	"
R214	"	22 K 1/2W 5%	" "	301119
R215	"	10 K 1/2W 5%	" "	301111
R216	"	270 K 1/2W 5%	" "	301145
R217	"	240 K 1/2W 5%	" "	301144
R218	"	10 K 1/2W 5%	" "	301111
R219	"	15 K 1/2W 5%	" "	301115
R220	"	10 K 1/2W 5%	" "	301111
R221	"	10 K 1/2W 5%	" "	301111
R222	"	12 K 1/2W 5%	" "	301113
R223	"	3.9 K 1/2W 5%	" "	301101
R224	"	12 K 1/2W 5%	" "	301113
R225	"	100 K 1/2W 5%	" "	301135
R226	"	100 K 1/2W 5%	" "	"
R227	"	15 K 1/2W 5%	" "	301115
R228	"	10 K 1/2W 5%	" "	301111
R229	"	100 K 1/2W 5%	" "	301135
R230	"	12 K 1/2W 5%	" "	301113
R231	"	4.7 K 1/2W 5%	" "	301103
R232	"	100 K 1/2W 5%	" "	301135
R233	Trimmer	1 K	Bourns 3007P-1-102	311256
R234	Resistor	100 K 1/2W 5%	AB EB	301135
R235	"	100 K 1/2W 5%	" "	301135
R236	"	27 K 1/2W 5%	" "	301121
R237	"	100 K 1/2W 5%	" "	301135
R238	"	100 K 1/2W 5%	" "	301135
R239	"	1.6 K 1/2W 5%	" "	301092
R240	"	470 Ω 1/2W 5%	" "	301079
R241	"	62 Ω 1W 5%	AB GB	302072
R242	"	150 K 1/2W 5%	AB EB	301139
R301	Resistor	130 Ω 1/2W	AB EB	301066
R302	"	470 K 1/2W 5%	" "	301151
R303	Var. Resistor		Bourns 3007P-1-102	311256

Reference		Description		BEC Part No.
R304	Resistor	10 K 3/8W 1%	T.I. MC60D	326376
R305	"	470 K 1/2W 5%	AB EB	301151
R306	"	51.1 kΩ 3/8W 1%	T.I. MC60D	340443
R307	"	2.49 K 3/8W 1%	T.I. MC60D	340287
R308	Var. Resistor		Bourns 3007P-1-102	311256
R309	Resistor	28.7 kΩ 3/8W 1%	T.I. MC60D	340414
R310	"	205 kΩ 3/8W 1%	T.I. MC60D	340516
R311	"	100 K 3/8W 1%	T.I. MC60D	340478
R312	"	39.2 kΩ 3/8W 1%	T.I. MC60D	340430
R313	"	182 kΩ 3/8W 1%	T.I. MC60D	340510
R314	"	11 K 3/8W 1%	T.I. MC60D	340364
R315	"	470 K 1/2W 5%	T.I. MC60D	301151
R316	"	28.7 kΩ 3/8W 1%	T.I. MC60D	340414
R317	"	97.6 kΩ 3/8W 1%	T.I. MC60D	340477
R318	Var. Resistor		Bourns 3007P-1-102	311256
R319	Resistor	28.0 K 3/8W 1%	T.I. MC60D	340412
R320	"	64.9 kΩ 3/8W 1%	T.I. MC60D	340456
R321	"	100 M 3/8W 1%	T.I. MC60D	326700
R322	"	24.9 K 3/8W 1%	T.I. MC60D	326389
R323	"	46.4 K 3/8W 1%	T.I. MC60D	340438
R324	"	10 K 3/8W 1%	T.I. MC60D	326376
R325	"	470 K 1/2W 5%	T.I. MC60D	301151
R326	"	38.3 kΩ 3/8W 1%	T.I. MC60D	340428
R327	"	2.49K 3/8W 1%	" "	340287
R328	Var. Resistor		Bourns 3007P-1-102	311256
R329	Resistor	390 kΩ 1/2W 5%	AB EB	301149
R330	"	21.0 kΩ 3/8W 1%	T. I. MC60D	340399
R331	"	154 kΩ 3/8W 1%	" "	340501
R332	"	39 kΩ 1/2W 5%	AB EB	301125
R333	"	33.2 kΩ 3/8W 1%	T. I. MC60D	340421
R334	"	154 K 3/8W 1%	" "	340501
R335	"	47 K 1/2W 5%	AB EB	301127
R336	"	41.2 kΩ 3/8W 1%	T.I. MC60D	340432
R337	"	124 kΩ 3/8W 1%	" "	340490
R338	"	470 K 1/2W 5%	AB EB	301151
R339	"	59.0 kΩ 3/8W 1%	T.I. MC60D	340451
R340	"	127 kΩ 3/8W 1%	" "	340491
R341	Var. Resistor		Bourns 3007-1-102	311256
R342	Resistor	41.2 kΩ 3/8W 1%	T.I. MC60D	340432
R343	"	2.74 K 3/8W 1%	" "	340292
R344	"	470 K 1/2W 5%	AB EB	301151
R345	"	22.1 kΩ 3/8W 1%	T.I. MC60D	326385
R346	"	294 kΩ 3/8W 1%	" "	340535
R347	Var. Resistor		Bourns 3007P-1-102	311256
R348	Resistor	37.4 kΩ 3/8W 1%	T.I. MC60D	340427
R349	"	309 kΩ 3/8W 1%	" "	340537
R350	"	470 K 1/2W 5%	AB EB	301151
R351	"	69.8 kΩ 3/8W 1%	T.I. MC60D	340460
R352	"	255 kΩ 3/8W 1%	" "	340527

Reference		Description		BEC Part No.
R353	Var. Resistor		Bourns 3007P-1-102	311256
R354	Resistor	16.5 K 3/8W 1%	T.I. MC60D	326381
R355	"	2.49 K 3/8W 1%	" "	340287
R356	"	33.2 kΩ 3/8W 1%	" "	340421
R357	"	499 kΩ 3/8W 1%	" "	326561
R359	"	64.9 kΩ 3/8W 1%	" "	340456
R360	"	324 kΩ 3/8W 1%	" "	340540
RT301	Thermistor	100 Ω 10%	Fenwal CB21J1	325005
R401	Var. Resistor	8 kΩ 10%	Fenwal JA38J1	325008
R402	Resistor	76 kΩ 3/8W 1%	T.I. MC60D	340465
R403	"	499 kΩ 3/8W 1%	" "	326561
R404	"	590 kΩ 3/8W 1%	" "	340571
R405	"	499 kΩ 3/8W 1%	" "	326561
R406	"	226 kΩ 3/8W 1%	" "	340521
R407	"	715 kΩ 3/8W 1%	" "	340581
R408	"	82 kΩ 1/2W 5%	AB EB	301133
R409	"	2.7 kΩ 1/2W 5%	" "	301097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R103
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R105
10K
R101
100
C101
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R102
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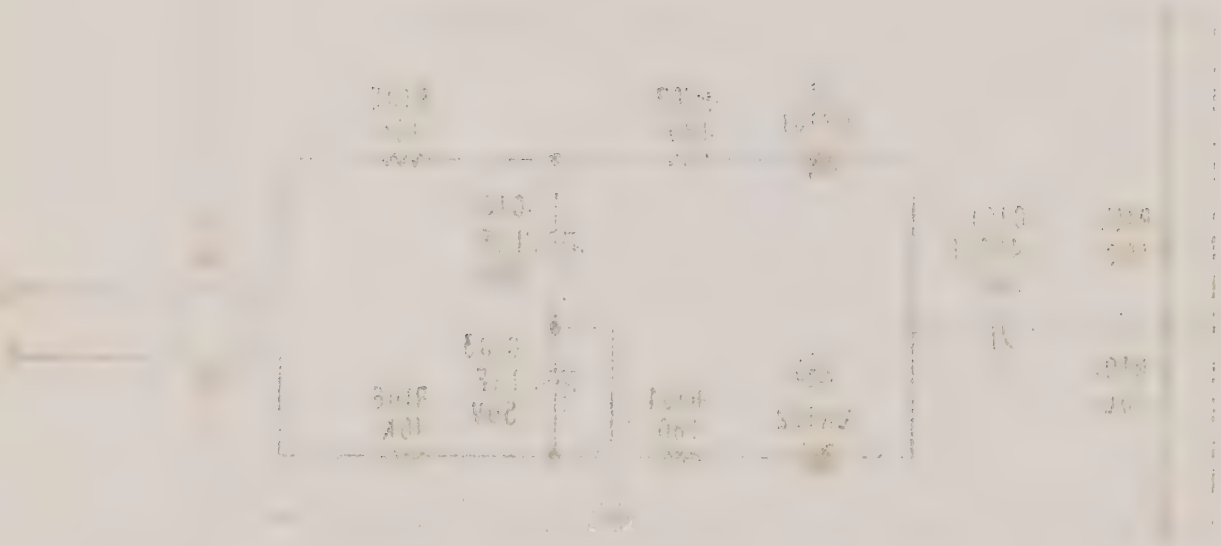
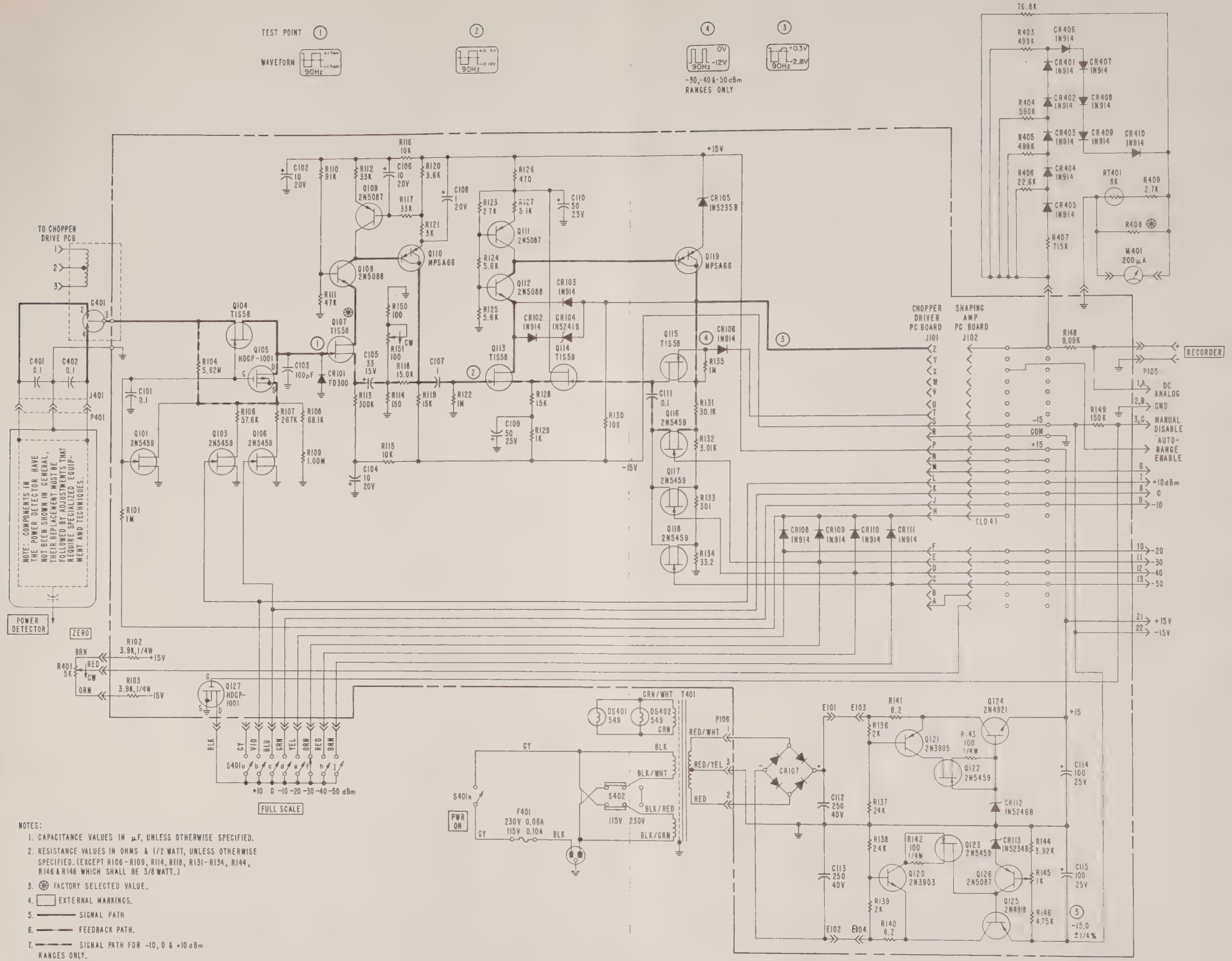
CR102
R104
180
R106
10K





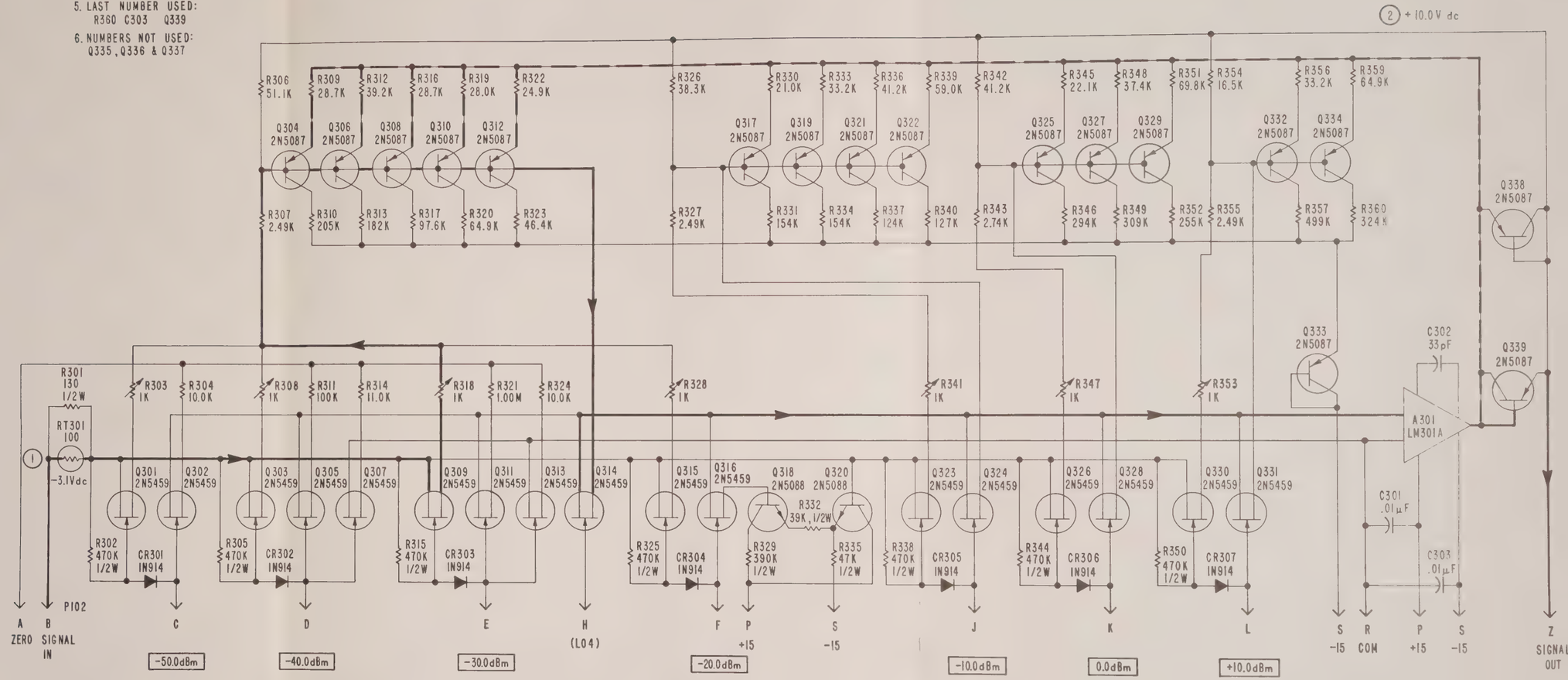
NOTES:

1. CAPACITANCE VALUES IN μF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS & 1/2 WATT, UNLESS OTHERWISE SPECIFIED. (EXCEPT R106-R109, R114, R118, R131-R134, R144, R146 & R148 WHICH SHALL BE 3/8 WATT.)
3. ⊛ FACTORY SELECTED VALUE.
4. ▭ EXTERNAL MARKINGS.
5. ——— SIGNAL PATH
6. ——— FEEDBACK PATH.
7. ——— SIGNAL PATH FOR -10, 0 & +10 dBm RANGES ONLY.
8. TEST CONDITIONS:
   -30 dBm RANGE
   -30 dBm SIGNAL
9. LAST NUMBERS USED:
   R151 C115
   R409 C402
10. NUMBERS NOT USED:
    R105, R147 & Q102

BOONTON ELECTRONICS CORPORATION

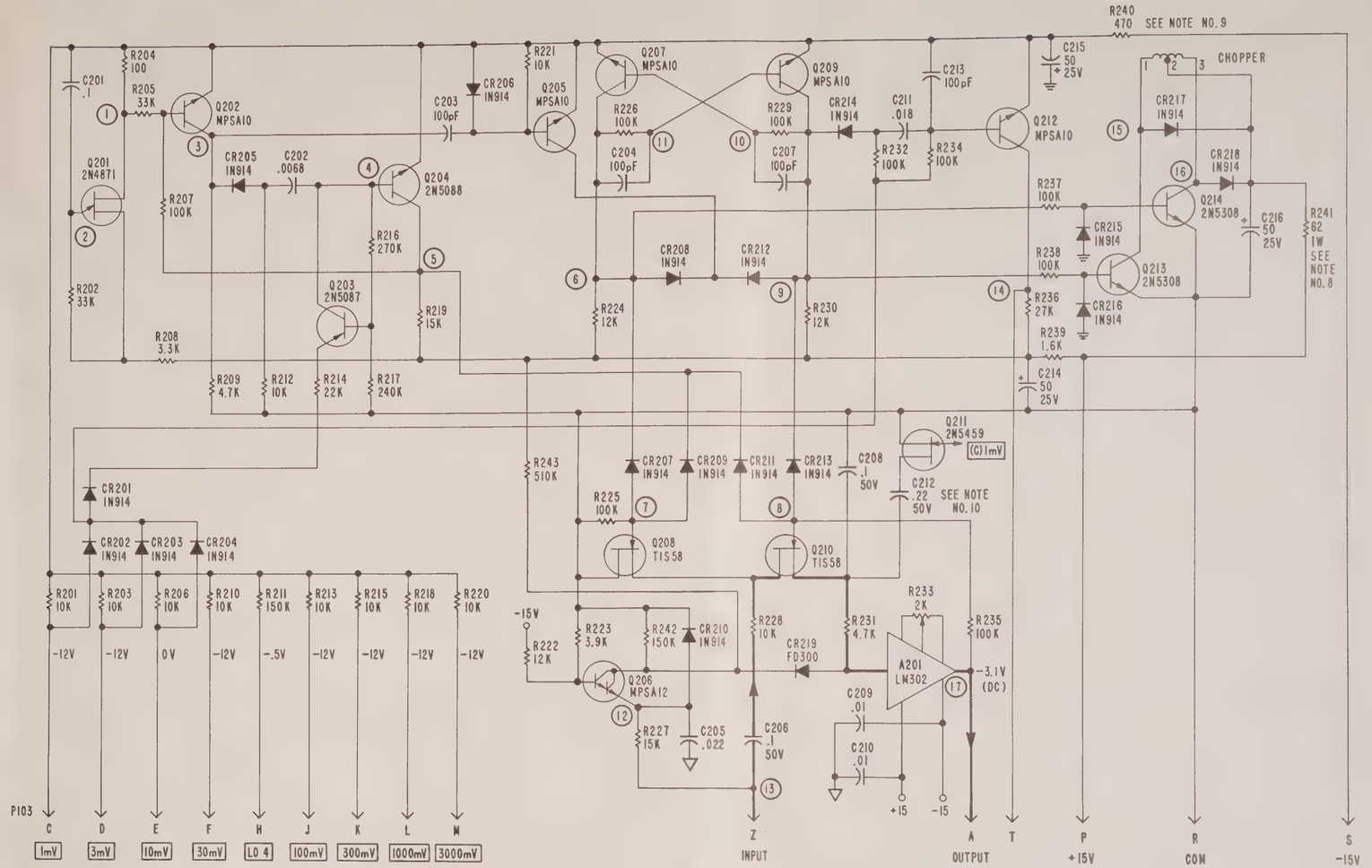
MODEL 42A
Schematic, Amplifier
830482D (Sh. 1 of 2)

NOTES:
1. RESISTANCE VALUES IN OHMS AND 3/8 WATT, UNLESS OTHERWISE SPECIFIED.
2. SIGNAL PATH ——
3. FEEDBACK PATH — — —
4. ▭ EXTERNAL MARKINGS
5. LAST NUMBER USED:
   R360 C303 Q339
6. NUMBERS NOT USED:
   Q335, Q336 & Q337



BOONTON ELECTRONICS CORPORATION

MODEL 42A
Schematic, Shaping Amp
830482D (Sh. 2 of 2)



TEST POINT ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ ⑪ ⑫ ⑬ ⑭ ⑮ ⑯

WAVEFORM

2mS ABOVE 10mV RANGE

LOW 3 RANGES ONLY

NOTES:

1. CAPACITANCE VALUES IN μF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS & 1/2 WATT, UNLESS OTHERWISE SPECIFIED.
3. ▭ EXTERNAL MARKINGS.
4. ▽ COMMON
5. ——— SIGNAL PATH
6. TEST CONDITIONS: 10mV RANGE 10mV SIGNAL
7. LAST NUMBERS USED: R242 C216 Q214 CR219
8. ON MODEL 92AB THIS VALUE IS 270Ω, 1/2W.
9. ON MODELS 92AD & 42AD THIS VALUE IS 300Ω, 1/2 WATT.
10. ON MODELS 92AD & 42AD THIS VALUE IS 0.47μF, 50V.

BOONTON ELECTRONICS CORPORATION

MODEL 42A
Schematic, Chopper Driver
830456J (Sh. 2 of 3)

Warranty

Boonton Electronics Corporation warrants its products to the original Purchaser to be free from defects in material and workmanship and to operate within applicable specifications for a period of one year from date of shipment, provided they are used under normal operating conditions. This warranty does not apply to vacuum tubes that have given normal service, to sealed assemblies which have been opened, or to any item which has been repaired or altered without our authorization.

We will repair or, at our option, replace at no charge any of our products which are found to be defective under the terms of this warranty. Except for such repair or replacement, we will not be liable for any incidental damages or for any consequential damages, as those terms are defined in Section 2-715 of the Uniform Commercial Code, in connection with products covered by this warranty.

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